

5.0. ENVIRONMENTAL RESOURCES

This section compares the results of the no-action projections for the study area and the projected landscape alterations associated with Alternatives 1 and 2. In all cases, except where specifically stated, the no-action projections for 30- and 100-years are also described in Step H (LADNR 1998h.i). Where deviations have been made, usually because of development and refinement of the approach, these refined methodologies are described. As in Step H (LADNR 1998h.i), the interaction between emergent and open water habitats and aquatic and other fauna will be addressed by examining three types of changes between the no-action and Alternatives 1 and 2 projections.

Section 5.1 discusses changes from current emergent (largely coastal wetland) habitats to projected open water under no-action and the effect of the alternatives on this change. Section 5.2 deals with changes in emergent habitat type based upon physical changes within the study area, such as those associated with alterations to water level or salinity. Section 5.3 discusses changes in the habitat and faunal utilization of open water areas as these change from their projected no-action status to that projected for the alternatives.

The assumption made in Step H (LADNR 1998h.i) was that there was unlikely to be conversion from current open water to emergent habitat in the future. This section considers where land is created in association with the alternatives.

5.1. Emergent Habitat To Open Water

5.1.1. Derivation of No-Action Land Loss Projections

As discussed in Section 2.1.1, land loss projections for the no-action scenario developed under Step H (LADNR 1998h.i) were modified for use in preparing Step J. The rate of land loss along the marsh shoreline was determined so that any change in wave height could be assessed. In addition, a new boundary was used for generating the

habitat acreage numbers. This is slightly different from that used in Step H (LADNR 1998h.i); therefore, new habitat acreages for no-action are also presented here to make the comparisons consistent.

5.1.2. Derivation of Alternative Projections

There are two main differences between the no-action and Alternatives 1 and 2 projections: 1) change in land loss rates to account for protection of bay shorelines, and 2) change in land masses along the barrier shorelines directly associated with the construction of Alternatives 1 and 2.

In order to estimate the effect of the alternatives on shoreline erosion around the coastal bays, wave models (Section 4.0) were used to provide data on the height of waves affecting these shorelines under no-action conditions (30- and 100-year projections) and for each alternative. For each shoreline polygon used in the projection of land loss, the change in wave height was assessed. It was assumed that waves less than 10 cm (3.9 inches) in height had an insignificant effect on erosion of the marsh edge. Thus, where waves were below this threshold under no-action, no changes were applied for the alternatives. However, several polygons did show changes in wave height and on the basis of these changes associated with the alternatives land loss rates in the shoreline polygons were modified. An 80% reduction in wave height resulting in a reduction in land loss of 96% is usually associated with the combined use of barrier restoration and wave absorbers in Alternative 1. Smaller reductions in land loss occur for most of the polygons in Alternative 2 as the barrier restoration configuration is different and there are no wave absorbers to effect regenerated waves in the coastal bays. Table 5-1 shows the modification to land loss in the various shoreline polygons for Alternative 1 and Alternative 2 for both 30- and 100-year projections.

**Table 5-1. Approach and Calculations for Loss Prevention Along Bay Shorelines
Associated with Alternatives 1 and 2.**

Polygon	No-Action 30-Year	Percent reduction in wave height for average wave height > 10 cm (30-Year)		Loss Prevention 30-Year (hectares)	
Area	Land Loss (hectares)	Alternative 1	Alternative 2	Alternative 1	Alternative 2
F1	213	-80%	0%	204	0
F2	708	-59%	-21%	589	266
F3	2,543	-80%	0%	2,441	0
F4	472	0%	0%	0	0
F5	4,232	0%	0%	0	0
S1	1,294	0%	0%	0	0
S2	395	-80%	0%	379	0
S3	1,261	0%	-2%	0	50
Total	11,118			3,613	316

Polygon	No-Action 100-Year	Percent reduction in wave height for average wave height > 10 cm (100-Year)		Loss Prevention 100-Year (hectares)	
Area	Land Loss (hectares)	Alternative 1	Alternative 2	Alternative 1	Alternative 2
F1	512	-80%	-10%	491	97
F2	1,480	-81%	-63%	1,427	1,278
F3	4,862	-80%	-31%	4,668	1,332
F4	1,070	-55%	-49%	853	792
F5	12,294	0%	0%	0	0
S1	2,851	0%	0%	0	0
S2	727	-80%	-6%	698	85
S3	3,142	0%	0%	0	0
Total	26,938			8,137	3,584

1 ha = 2.47 acres

In addition, changes in the barrier shoreline configuration associated with the design of the alternatives results in an increase in emergent habitat. Table 5-2 shows the habitat change associated with the two alternatives.

Table 5-2. Modifications to Emergent habitats associated with Construction of Alternatives (ha)

	Alternative 1	Alternative 2
Island habitat		
Beach	967	977
Vegetated Dune	391	394
Saline Marsh	4,990	2,637
Total Land	6,348	4,008
1 ha = 2.47 acres		

5.1.2.1. Alternative 1

In Figure 5-1, the 30-year no-action projection is overlain on the 1988/90 habitat data using the procedures described in Step H (LADNR 1998h.i). Figure 5-2 shows the same approach applied to the 100-year projection. The 30-year and 100-year projections for land-water associated with Alternative 1 are shown in Figures 5-3 and 5-4 respectively. They are also overlaid on this habitat map. In addition, Figures 5-3 and 5-4 include habitats created along the barrier shorelines. Table 5-3 shows the difference in acreage of various emergent habitats for the 30- and 100-year no-action and Alternative 1 comparisons.

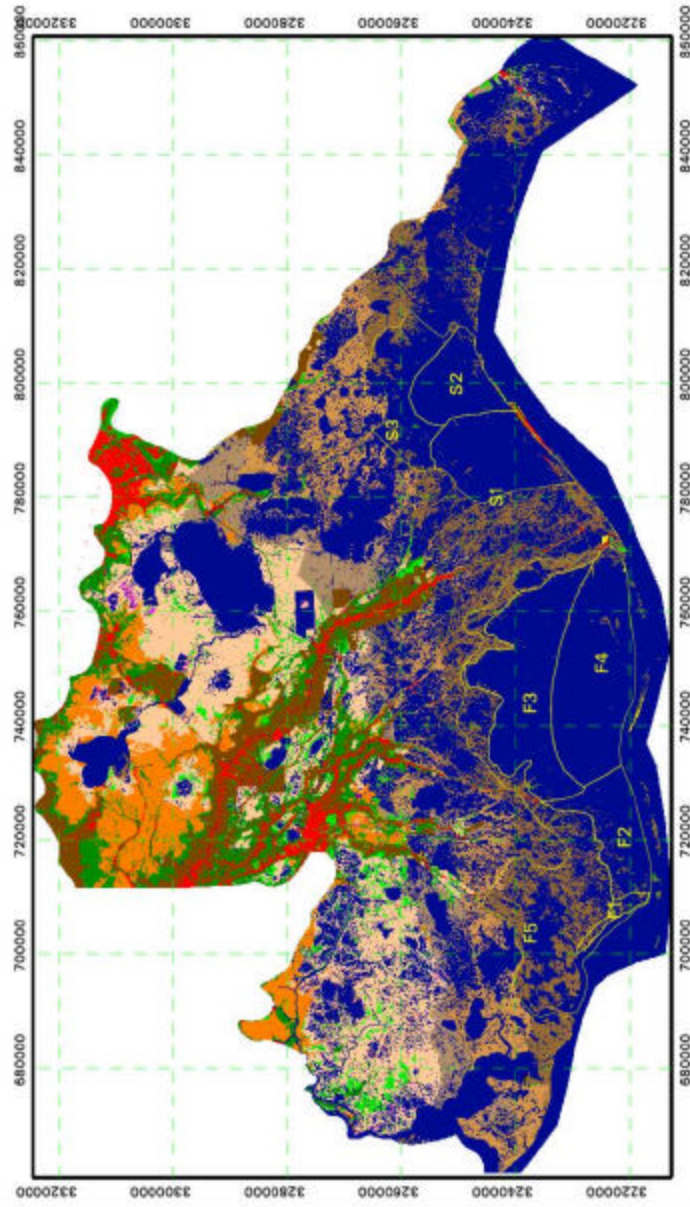
Table 5-3. Alternative 1 Habitat Distribution (hectares)

	30-year No-Action	30-year Alternative 1	Change	100-year No-Action	100-year Alternative 1	Change
Water	602809	593066	-9743	727451	712624	-14827
AB floating	2206	2206	0	1325	1325	0
AB Submerged	1703	1704	1	905	907	2
Fresh marsh	131897	131896	-1	106419	106419	0
Intermediate marsh	37318	37318	0	28755	28755	0
Brackish marsh	64308	64294	-14	46625	46617	-8
Saline marsh	12162	130220	8,599	71301	84422	13121
Cypress forest	63127	63127	0	54785	54785	0
Bottomland forest	58295	58294	-1	53985	53985	0
Upland forest	6127	6136	9	5428	5453	25
Dead forest	95	95	0	51	51	0
Bottomland scrub	21951	21903	-48	18283	18404	121
Upland scrub	3725	3636	-89	2285	2369	84
Shore/flat	812	2098	1286	474	959	485
AG/pasture	71724	71775	51	70333	70386	53
Upland barren	303	253	-50	240	227	-13
Developed	29535	29535	0	28922	28922	0
Other	14	13	-1	4	6	2
TOTAL	1217569	1217572		1217570	1217572	

1 hectare = 2.47 acres

1 square mile = 259 hectares

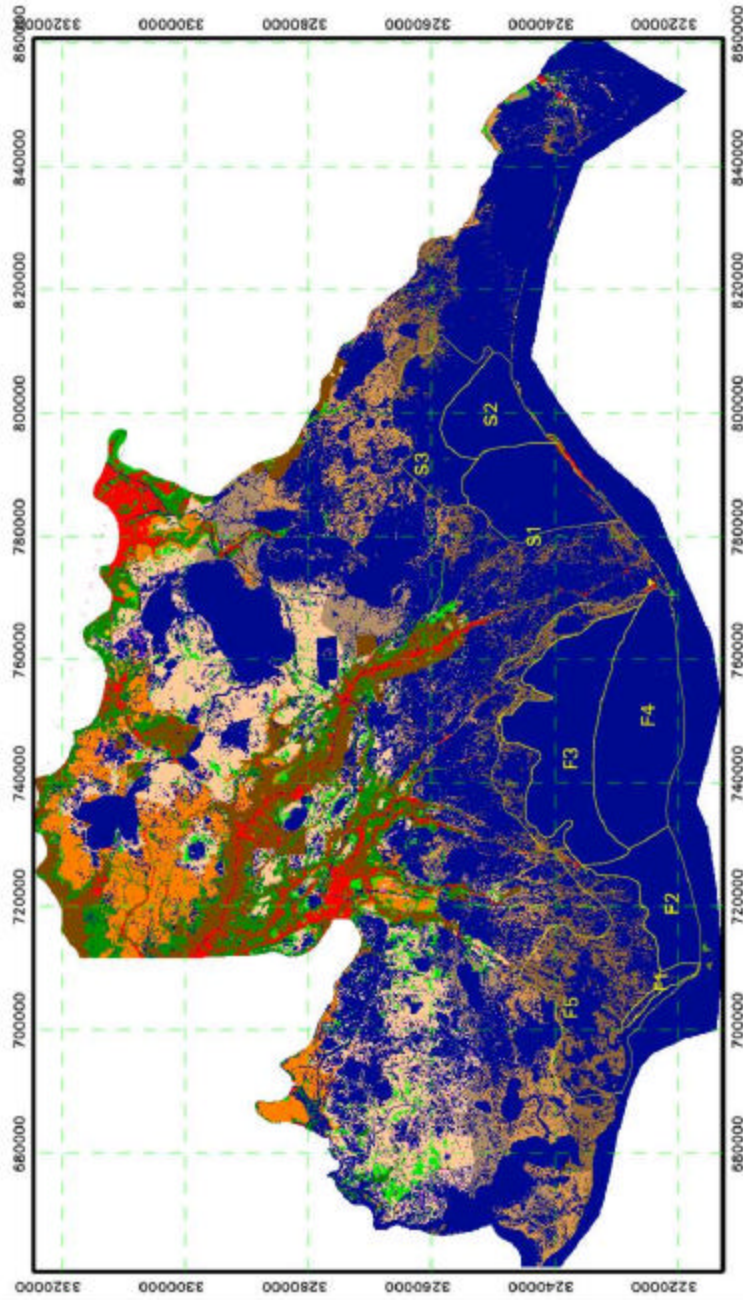
Figure 5-1. Projected Coastal Habitat (30-year, No-Action)



Habitat	Area (Acres)
Water-----	1489569
AB Floating-----	5452
AB Submerged-----	4207
Fresh Marsh-----	325923
Intermediate Marsh-----	92214
Brackish Marsh-----	158908
Saline Marsh-----	300531
Cypress Forest-----	155989
Bottomland Forest-----	144050
Upland Forest-----	15139
Dead Forest-----	234
Bottomland Shrub-----	54242
Upland Shrub-----	9204
Shore/Flat-----	2006
AG/Pasture-----	177232
Upland Barren-----	749
Developed-----	72983
Other Land-----	35

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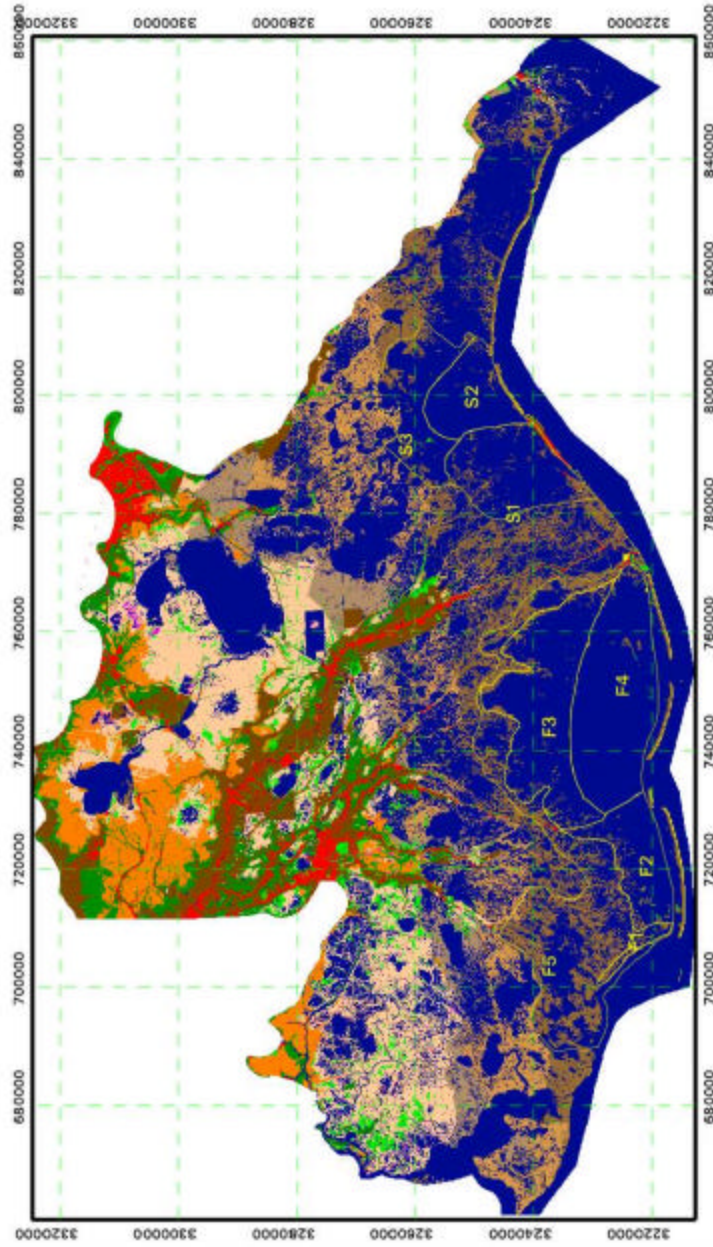
Figure 5-2. Projected Coastal Habitat (100-Year, No-Action)



Habitat	Area (Acres)
Water-----	1797563
AB Floating-----	3273
AB Submerged-----	2237
Fresh Marsh-----	262965
Intermediate Marsh	71056
Brackish Marsh----	115212
Saline Marsh-----	176188
Cypress Forest----	135377
Bottomland Forest--	133399
Upland Forest-----	13413
Dead Forest-----	125
Bottomland Shrub--	45177
Upland Shrub-----	5646
Shore/Flat-----	1172
AG/Pasture-----	173795
Upland Barren-----	592
Developed-----	71467
Other Land-----	11

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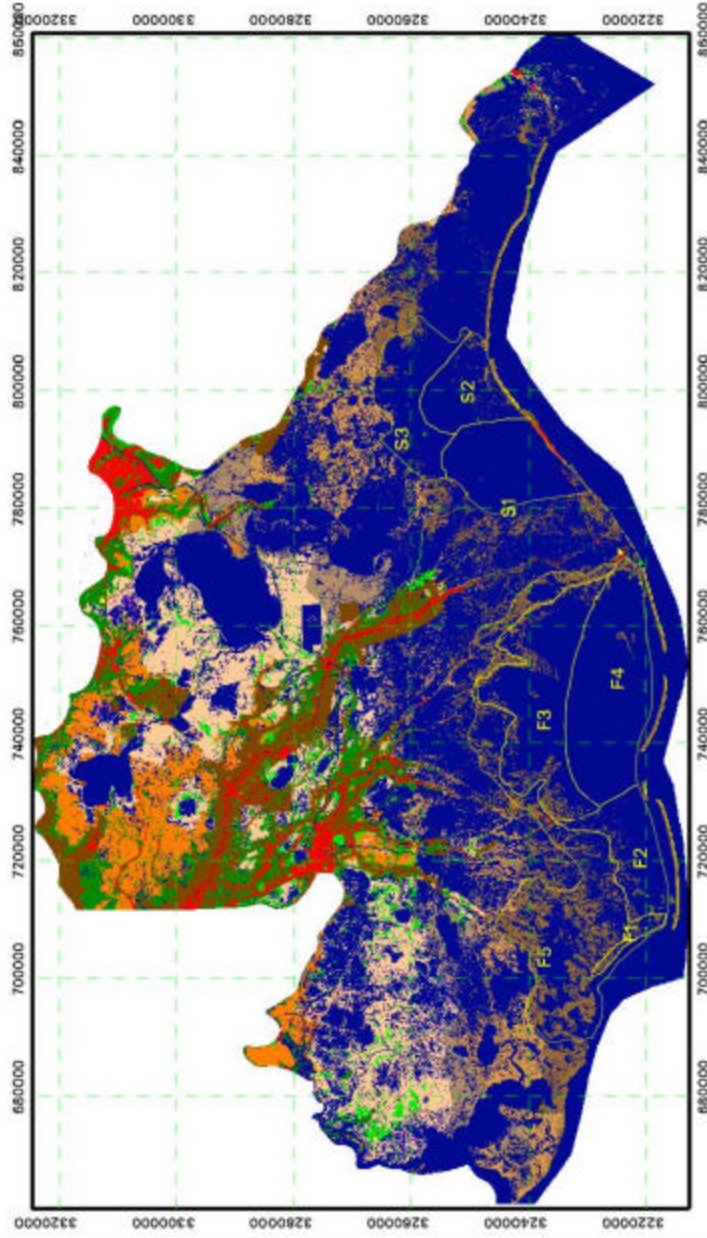
Figure 5-3. Projected Coastal Habitat (30-year, Alternative 1)



Habitat	Area (Acres)
Water-----	1465492
AB Floating-----	5452
AB Submerged-----	4210
Fresh Marsh-----	325920
Intermediate Marsh	92214
Brackish Marsh----	158873
Saline Marsh-----	321780
Cypress Forest----	155989
Bottomland Forest--	144050
Upland Forest-----	15163
Dead Forest-----	234
Bottomland Shrub--	54124
Upland Shrub-----	8984
Shore/Flat-----	5185
AG/Pasture-----	177358
Upland Barren-----	625
Developed-----	72983
Other Land-----	31

Prepared by NSEL/LSU, 1998

Figure 5-4. Projected Coastal Habitat (100-Year, Alternative 1)



Habitat	Area (Acres)
Water-----	1760924
AB Floating-----	3273
AB Submerged-----	2242
Fresh Marsh-----	262965
Intermediate Marsh	71056
Brackish Marsh----	115193
Saline Marsh-----	208611
Cypress Forest----	135377
Bottomland Forest--	133399
Upland Forest-----	13473
Dead Forest-----	125
Bottomland Shrub--	45476
Upland Shrub-----	5855
Shore/Flat-----	4729
AG/Pasture-----	173927
Upland Barren-----	561
Developed-----	71467
Other Land-----	16

Prepared By NSEL/LSU, 1998

The most prominent change shown in Table 5-3 is the decrease in open water and the increase in saline marsh and shore/flat habitat. Minor changes in brackish marsh, upland barren and agricultural/pasture lands are associated with the overlay of the new barrier configurations on the existing National Wetlands Research Center (NWRC) categorized habitats. Changes in upland forest are probably associated with the prevention of loss (maintenance of shoreline integrity) in the Caminada-Moreau areas where the maritime forest habitat on the beach ridges will be retained under Alternative 1. The decrease in scrub habitat and then increase in scrub habitat for the 30- and 100-year projections respectively is probably associated with the prevention of loss at the bay shoreline. Due to the remnants of the barrier shorelines in the 30-year no-action projection (Figure 5-1), the effect of Alternative 1 on bay shoreline erosion is maximized under the 100-year projection - when all the existing barriers have eroded in the no-action scenario (Figure 5-2). It appears there is some scrub habitat at the bay shoreline, as may be expected along dredged material levees or perhaps natural levees. Under the 30-year comparison some of this is lost. However, some land loss in these polygons is prevented in 100-years, as the effect of the alternative becomes more prominent against an increasing wave climate. Some of the prevention appears to be allocated to the "scrub" category. This is likely an artifact of the methodology used to prevent loss in the shoreline polygons, rather than an intended habitat impact associated with the alternative.

The net effect of Alternative 1, when compared to no-action, is an increase in marsh acreage by over 10,677 hectares (41.2 mi²). Shore/flat habitat (beach and dune in this case) increased by more than 1,415 hectares (5.5 mi²). The distribution of these enhanced habitats can be seen by comparing Figures 5-1 and 5-2 with Figures 5-3 and 5-4. Apart from the barrier shoreline, the main effect of Alternative 1 is to maintain the marsh shoreline integrity on the landward side of the coastal bays. The patterns shown in Figures 5-3 and 5-4 may not project the exact land configuration, due to the methods used to manipulate the Geographic Information System (GIS) and impartially depict land loss prevention. These benefits are located in the saline marsh areas landward of the coastal

bays. At present, no substantial land loss effects to interior marshes associated with the alternatives is anticipated.

5.1.2.2. Alternative 2

Figures 5-5 and 5-6 show the 30- and 100-year projections of land-water associated with Alternative 2 and are overlain on the 1988/90 habitat map. Figures 5-5 and 5-6 also include habitats created along the barrier shorelines in Alternative 2. Table 5-4 indicates the difference in acreage of various emergent habitats for the 30- and 100-year no-action and Alternative 2 comparisons.

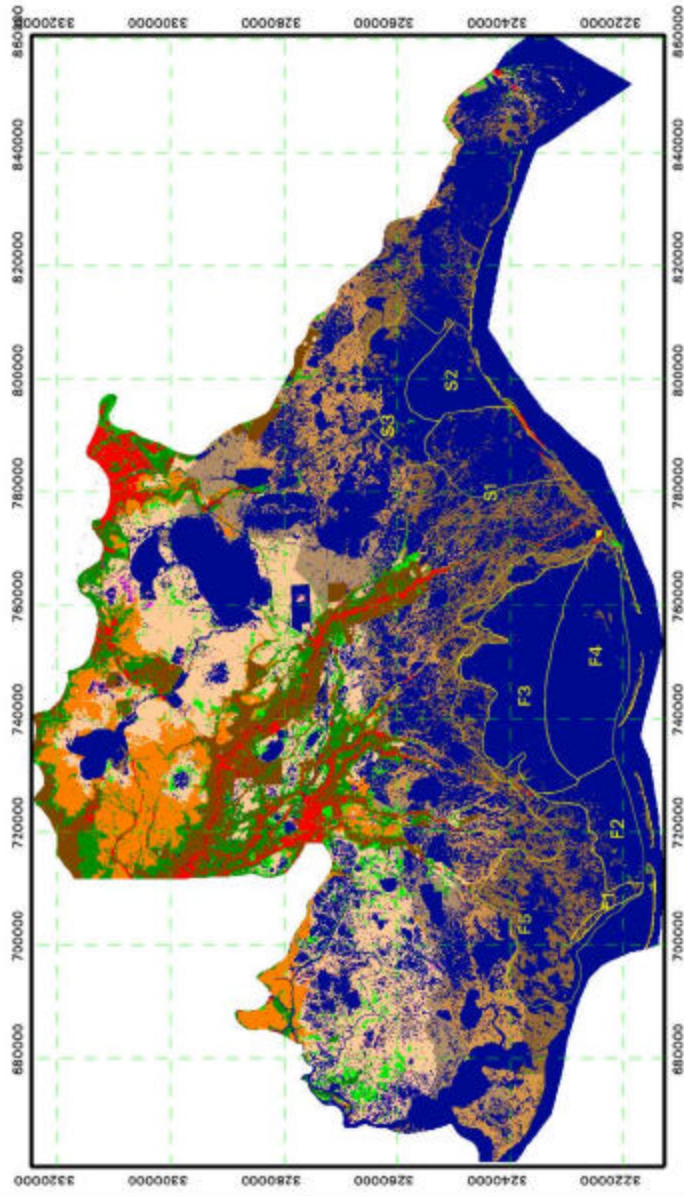
Table 5-4. Alternative 2 Habitat Distribution (hectares)

	30-year No-Action	30-year Alternative 2	Change	100-year No-Action	100-year Alternative 2	Change
Water	602810	598889	-3921	727451	719712	-7739
AB floating	2206	2206	0	1325	1325	0
AB Submerged	1703	1703	0	905	907	2
Fresh marsh	131897	131896	-1	106419	106418	-1
Intermediate marsh	37318	37318	0	28755	28756	1
Brackish marsh	64308	64300	-8	46625	46618	-7
Saline marsh	121621	124574	2953	71301	77520	6219
Cypress forest	63127	63128	1	54785	54786	1
Bottomland forest	58295	58296	1	53985	53986	1
Upland forest	6127	6127	0	5428	5450	22
Dead forest	95	95	0	51	51	0
Bottomland scrub	21951	21898	-53	18283	18397	114
Upland scrub	3725	3625	-100	2285	2339	54
Shore/flat	812	1965	1153	474	1798	1324
AG/pasture	71724	71756	32	70333	70369	36
Upland barren	295	256	-39	239	227	-12
Developed	29535	29532	-3	28922	28912	-10
Other	14	13	-1	4	6	2
TOTAL	1217569	1217591		1217570	1217591	

1 hectare = 2.47 acres

1 square mile = 259 hectares

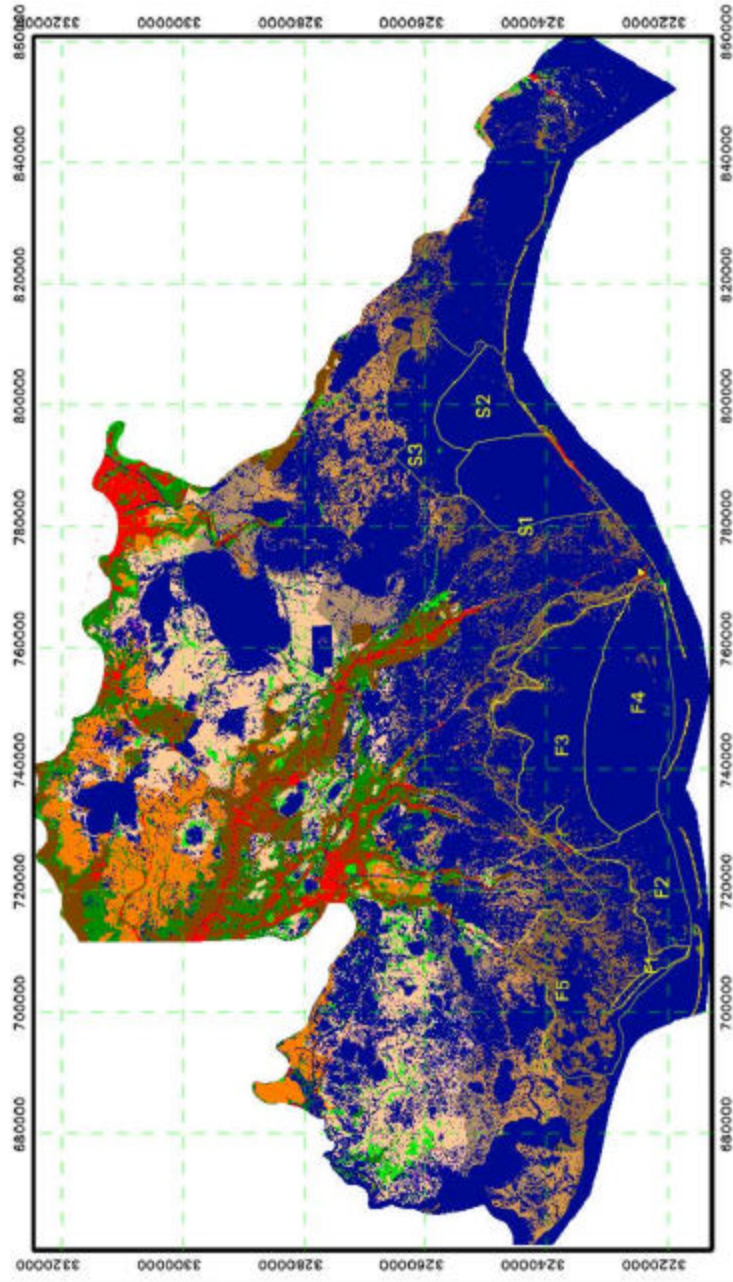
Figure 5-5. Projected Coastal Habitat (30-Year, Alternative 2)



Habitat	Area (Acres)
Water-----	1479882
AB Floating-----	5452
AB Submerged-----	4209
Fresh Marsh-----	325916
Intermediate Marsh-----	92214
Brackish Marsh-----	158886
Saline Marsh-----	307827
Cypress Forest-----	155989
Bottomland Forest-----	144050
Upland Forest-----	15139
Dead Forest-----	234
Bottomland Shrub-----	54110
Upland Shrub-----	8958
Shore/Flat-----	4855
AG/Pasture-----	177310
Upland Barren-----	632
Developed-----	72973
Other Land-----	32

Prepared By NSEL/LSU, 1998

Figure 5-6. Projected Coastal Habitat (100-Year, Alternative 2)



Habitat	Area (Acres)
Water-----	1778441
AB Floating-----	3273
AB Submerged-----	2242
Fresh Marsh-----	262960
Intermediate Marsh	71056
Brackish Marsh----	115193
Saline Marsh-----	191555
Cypress Forest----	135377
Bottomland Forest--	133399
Upland Forest-----	13466
Dead Forest-----	125
Bottomland Shrub--	45459
Upland Shrub-----	5779
Shore/Flat-----	4443
AG/Pasture-----	173883
Upland Barren-----	560
Developed-----	71442
Other Land-----	16

Prepared By NSEL/LSU, 1998

Again, the most prominent change shown in Table 5-4 is the decrease in open water and the increase in saline marsh and shore/flat habitat. Minor changes in brackish marsh, upland barren and agricultural/pasture lands are associated with the overlay of the new barrier configurations on the existing NWRC categorized habitats. Changes in upland forest are probably associated with the prevention of loss (maintenance of shoreline integrity) in the Caminada- Moreau areas where the maritime forest habitat on the beach ridges will be retained under Alternative 2. The decrease in scrub habitat and then increase in scrub habitat for the 30- and 100-year projections respectively is probably associated with the prevention of loss at the bay as described for Alternative 1. However, the changes in Alternative 2 are of different magnitude because of the different restoration configuration at the barrier and bay shorelines.

The net effect of Alternative 2, when compared to no-action, is an increase in marsh acreage by over 9,218 hectares (35.6 mi²) and shore/flat habitat (beach and dune in this case) by over 1,295 hectares (5.0 mi²). The distribution of these enhanced habitats can be seen by comparing Figures 5-1 and 5-2 with Figures 5-5 and 5-6. The main effect of Alternative 2 is to increase habitat at the barrier shoreline with some impact on the integrity of the marsh shoreline along the landward side of the coastal bays. At present, no significant direct effects on land loss in interior marshes of the Phase 1 Study Area are anticipated.

5.2 Changes In Emergent Habitats

5.2.1. Modeled Changes in Water Level

Similar modeling approaches to those used in Step G (LADNR 1998g) were used to project mean tidal levels across the study area associated with the alternatives. The analysis presented in Step H (LADNR 1998h.i) showed that, although there were projected changes in the flooding regime of some marsh areas, over 30- and 100-years these were unlikely to be ecologically significant. Repetition of this analysis shows no

change in the pattern of flooding associated with the alternatives. Sites that were flooded by average tidal activity under no-action are also flooded under the alternatives; any changes in magnitude are not considered ecologically significant for either alternative.

These analyses were conducted for scenarios that included the Davis Pond diversion operating (i.e., delivering water to upper Barataria Basin) and not operating (i.e., a time of year when the structure is closed). The results showed no difference between water levels in the study area (at the scale resolvable by the model) associated with the operation of the Davis Pond freshwater diversion structure. This implies there are no interactions between operation of Davis Pond and Alternatives 1 and 2 that will produce ecologically important changes in water level.

5.2.2. Modeled Changes in Salinity

The two-dimensional hydrologic model described above was used to project salinity changes associated with Alternatives 1 and 2. As discussed in Section 3.0, the model was run for both alternatives and a no-action scenario with and without Davis Pond operational. This provides an indication of the annual variation in salinities within the study areas associated with enhanced spring freshwater inputs from the structure and limited freshwater during fall. As this type of modeling had not been possible in Step H (LADNR 1998h.i), no-action scenarios were regenerated. The changes in salinity will be described here in terms of the possible effect on emergent habitat types.

5.2.2.1. Salinity Distribution for No-Action

The effect of the Davis Pond project on salinities in the Phase 1 Study Area is shown in Section 3.0 in Figures 3-13 to 3-16. These figures show the salinity distribution for the 30- and 100-year no-action projections. For no-action in 30-years, the marshes in the Little Lake and Bayou Perot/Rigolettes area are subjected to salinity variations over a year from effectively fresh to at least 3 ppt. With Davis Pond, decreased salinities occur

on the western side of Barataria Bay and the 3 ppt isohaline extends to the back of the barrier shoreline. For no-action in 100-years, the central Barataria Basin has opened up considerably with the loss of marshes between Little Lake and the bay constrictions at the north end of Bayou Perot preventing much exchange with Lake Salvador. With Davis Pond, large areas of the central Barataria basin will be 5-7 ppt, well within the tolerance of the area's existing brackish marshes.

These results confirm the conclusions of the analysis using the one-dimensional model of this part of the Barataria Basin used in Step H (LADNR 1998h.i). Given the salinity tolerances of marsh vegetation in these areas (Visser et al. 1996) no changes in emergent habitat are expected to occur under no-action conditions.

5.2.2.2. Alternative 1

The effect of the barrier shoreline configuration under Alternative 1 on salinities can be examined in association with the operation of the Davis Pond project. During the spring, when Davis Pond is assumed to be operating, the effect of maintaining the integrity of the barrier shoreline at the seaward margin of Barataria Basin are shown in Figures 5-7 and 5-8 (30- and 100-year projections respectively). As the interior wetlands deteriorate, lower salinities penetrate lower south into the basin as the shoreline limits the amount of higher salinity water penetrating from the south. The effect is most pronounced in the 100-year projection (Figure 5-8) where salinities between 1 and 3 ppt extend to the back of Grand Isle. However, in the fall condition when Davis Pond is not operating, salinities within the lower portion of Barataria Bay are greater than 15 ppt as shown in Figure 5-9. The net effect of these salinity changes is unlikely to be a change in the type of emergent habitat.

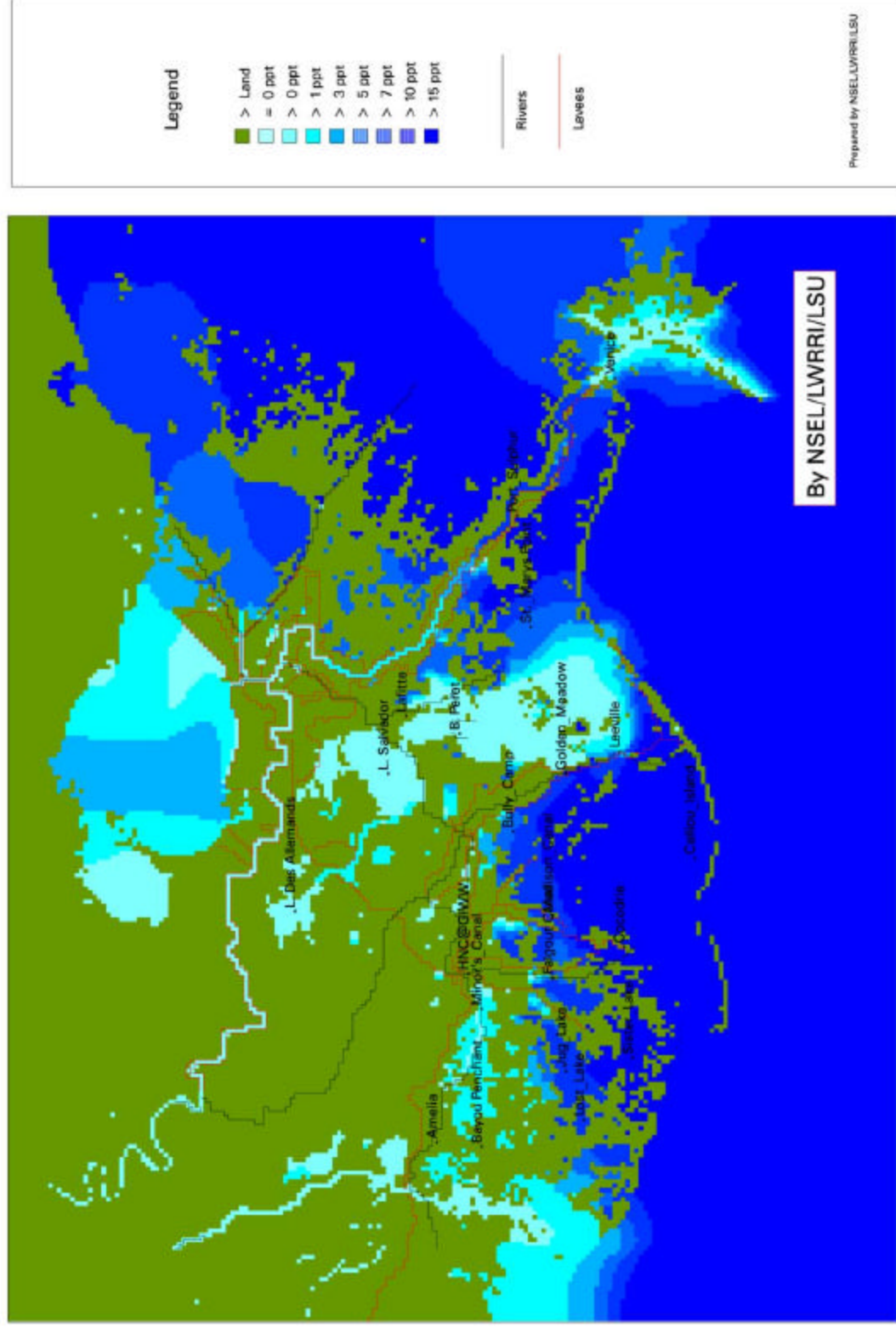
For the rest of the study area, and for the Barataria basin when Davis Pond is not operating (due to season, river stage, or other reasons), the changes in salinity associated with Alternative 1 compared to no-action are shown in Section 3.0 Figures 3-17 and 3-18. Within the basin the main changes are in lower Plaquemines Parish, south of Port

Sulphur, where increasing the integrity of a deteriorated shoreline will decrease the salinity penetration into the bays behind the shoreline. Small areas behind the barrier islands could experience salinity decreases as well. During the highest salinity times of the year, this could result in changes between 2-3 ppt. This is in addition to any effects caused by Davis Pond. In the lower part of the basin, these salinities are unlikely to change *Spartina alterniflora* marsh to *Spartina patens*. There may also be effects on fauna.

For the Terrebonne basin, the effect is more extensive. Closing the inlet between East Timbalier Island and the West Belle Pass headland area, as well as the constriction of Little Pass between East Timbalier and Timbalier Islands, will reduce salinities by more than 3 ppt. A similar, but less intense effect is shown in Lake Pelto behind the Isles Dernieres. Increases in salinity outside the barrier shorelines are artifacts of the modeling technique; they are not projected environmental effects of the alternative.

These salinity changes are unlikely to result in changes in emergent vegetative habitats. These changes occur in the basin, where salinity levels support salt marsh, because there are limited freshwater inputs to the coastal bays. The changes demonstrate the important interactions between maintaining the barrier shoreline configuration and enhancement of low salinity inputs to the basin's upper reaches. The model shows how barrier shorelines work to reduce salinity inputs and modulate exchanges. It is not known at present how these interactions are modified as freshwater increases into either Terrebonne or Barataria basins due to diversion projects.

Figure 5-8. Salinity Distribution (with Davis Pond, 100-year, Alternative 1)



5.2.2.3. Alternative 2

Salinity changes associated with Alternative 2 are similar, but of lesser magnitude than those for Alternative 1. During the spring, when Davis Pond is assumed to be operating, the effect of maintaining the integrity of the barrier shoreline at the seaward margin of Barataria Basin is shown in Figures 5-10 and 5-11 (30- and 100-year projections respectively). As the interior wetlands deteriorate, lower salinities penetrate lower south into the basin as the shoreline limits the amount of higher salinity water penetrating from the south. The effect is most pronounced in the 100-year projection (Figure 5-11) where salinities between 3 and 5 ppt extend to the back of Grand Isle. However, in the fall when Davis Pond is not operating, salinities within the lower portion of Barataria Bay are greater than 15 ppt as shown in Figure 5-12. The net effect of these salinity changes is unlikely to be a change in the type of emergent habitat.

For the rest of the study area, and for the Barataria basin when Davis Pond is not operating (due to season, river stage, or other reasons), the changes in salinity associated with Alternative 2, as compared to no-action, can be seen in Section 3.0 - Figures 3-21 and 3-22. The effects appear to be greater for the 30-year projection than for the 100-year projection. Figure 3-22 shows a small area of decreased salinity in lower Plaquemines Parish. This is apparently associated with lesser penetration of salinity in Alternative 2 as compared to the degraded barrier shoreline in the no-action scenario. There are similar effects behind East Timbalier and Timbalier Islands, as well as the Isles Dernieres. However, salinity decreases of up to 3 ppt in places have largely disappeared by the 100-year projection. Although the design of the alternatives calls for maintenance of the barrier shoreline during this period, the main effect here seems to be the continued opening of the interior wetlands. There is a larger volume of water in the system; the effect of limiting exchange through a few passes has less of an effect in such an open interior system.

These salinity changes are unlikely to result in changes in emergent vegetative habitats. These changes occur in the basin, where salinity levels support salt marsh, because there are limited freshwater inputs to the coastal bays. The changes demonstrate the important interactions between maintaining the barrier shoreline configuration and enhancement of low salinity inputs to the basin's upper reaches. The model shows how barrier shorelines work to reduce salinity inputs and modulate exchanges. It is not known at present how these interactions are modified as freshwater increases into either Terrebonne or Barataria basins due to diversion projects.

Figure 5-11. Salinity Distribution (with Davis Pond, 100-year, Alternative 2)

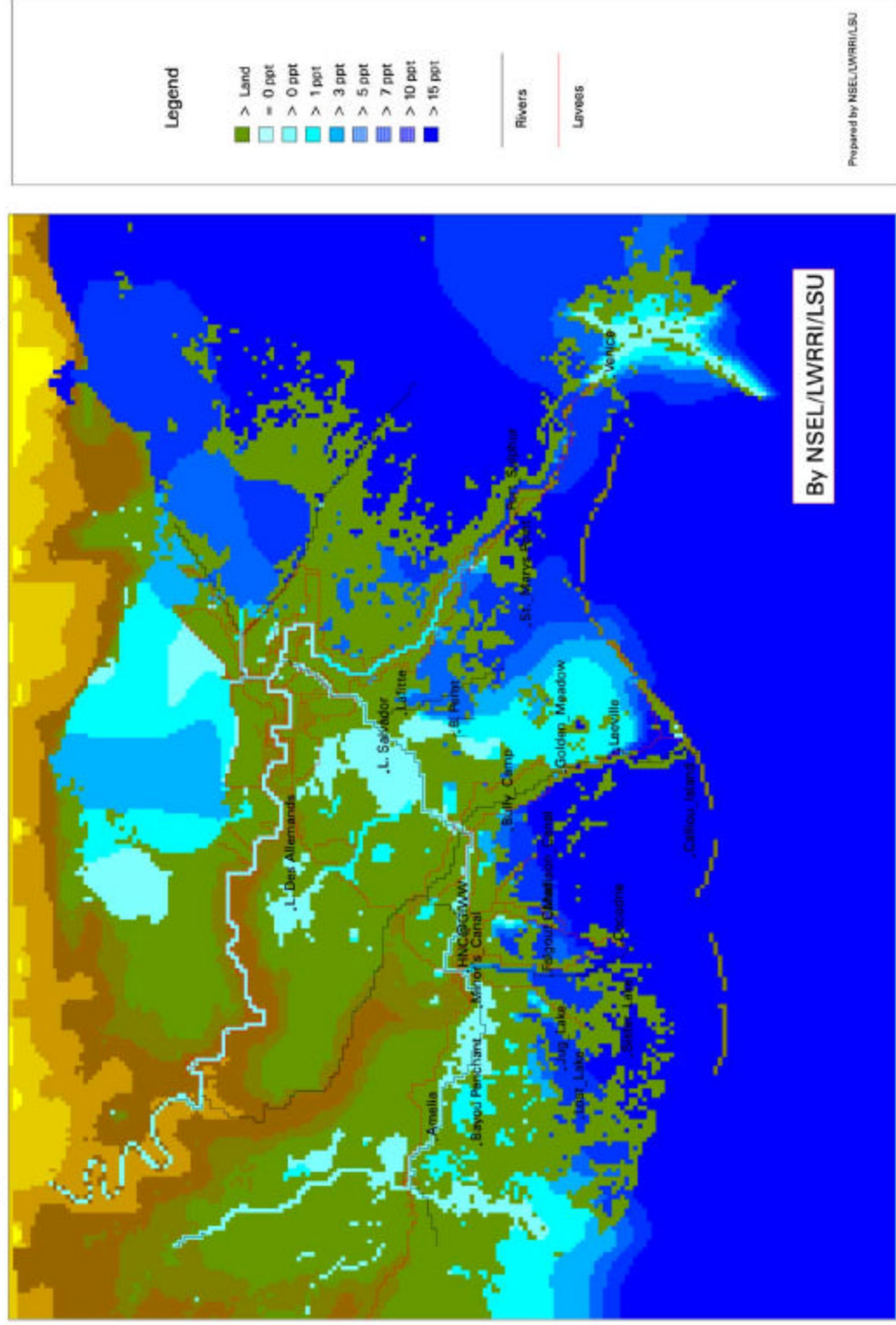
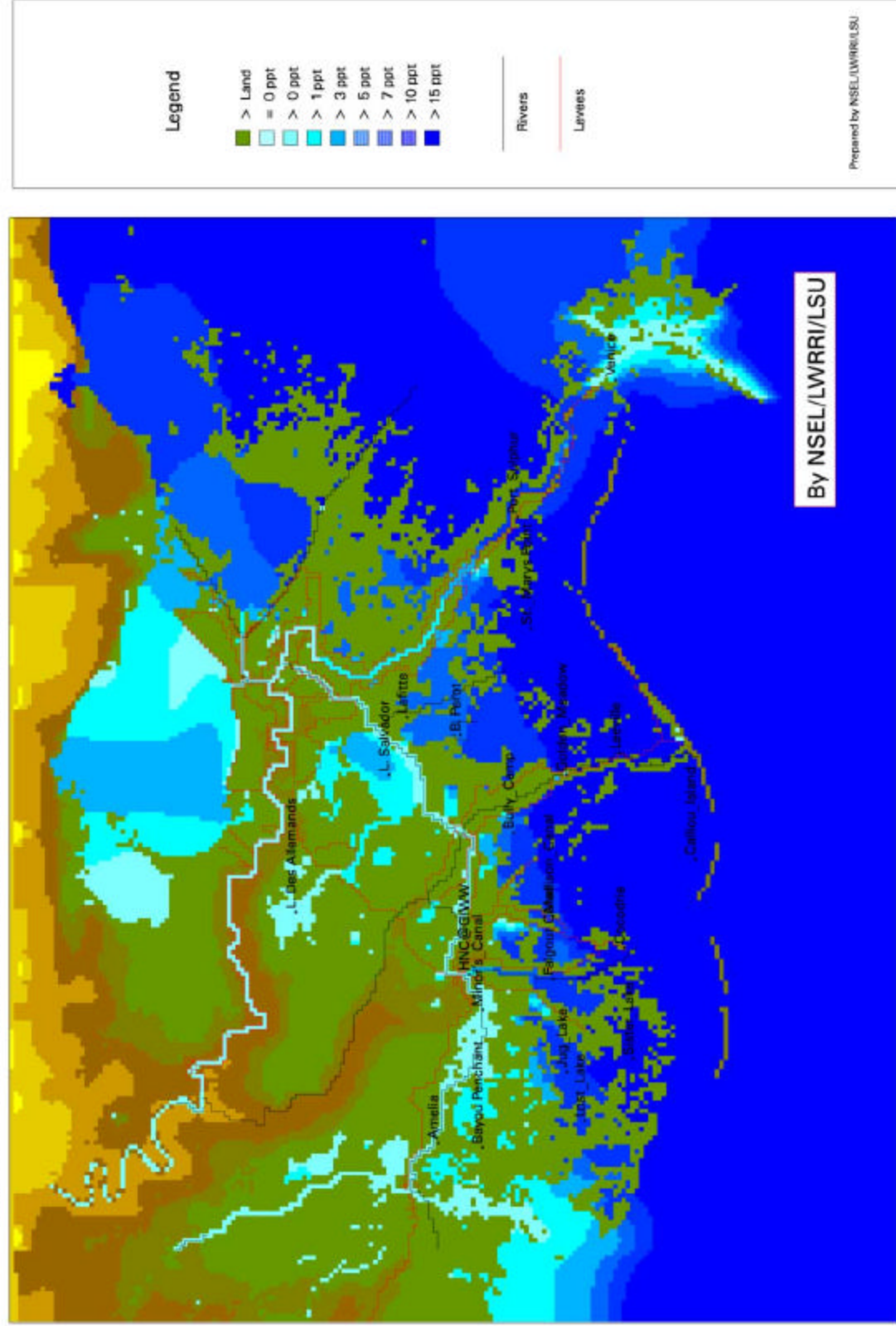


Figure 5-12. Salinity Distribution (w/o Davis Pond, 100-year, Alternative 2)



Time = 2160 Hr. (90 Days)

5.3. Changes In Open Water Habitats

Open water faunal habitats created as a result of land loss in part depends in part on their physiography (shape, size, depth, relation to other open water bodies) and regional salinities. Changes in the properties associated with the alternatives will be assessed for the wetland components based on the habitat images described in Section 5.1. As noted in Sections 5.1 and 5.2, changes associated with the alternatives, when compared to no-action, are in the lower parts of the study area. Effects on the upper parts of the system (intermediate, fresh marshes and wetland forests) will not be discussed. Trends in the following landscape parameters will be assessed:

- * fragmentation/interspersation
- * depth
- * connectivity to open bay

5.3.1. Alternative 1

5.3.1.1. Barrier Islands

Rebuilding barrier islands will increase dune area, beach and marsh habitats, as described in Section 5.1. There will be no change in salinity, with the exception of a seasonal decrease up to 3 ppt on the backside of the barrier shoreline. The trends are:

- * fragmentation/interspersation - reduced as inlets are closed and newly created back barrier marsh is likely include fewer channels and ponds than exists currently
- * depth - similar to present
- * connectivity - reduced due to nature of created marsh and closing of some inlets.

The barrier island ecosystem will still be functioning in the study area. The system will not be gone in the Terrebonne and Timbalier basins or badly deteriorated in

the Barataria basin as predicted in the no-action alternative. Important implications for local fauna will be:

- * high-energy beach habitat will serve as mating, pupping and nursery grounds for several species of sharks presently under a management plan designed to remedy a decline in population.
- * high-energy beach habitat will serve as nursery area for species, such as Florida pompano and Gulf Kingfish, that have no alternate nursery habitat.
- * beach and dune habitat will serve as nesting area for many species of shore and sea birds.
- * scrub and wooded areas will serve as important stop over habitats for migrating songbirds (and other trans-Gulf migrators), as well as nesting habitat for herons, egret and other species requiring support structures for nests.
- * barrier island marsh will serve as the initial nursery for many species of young-of-the-year estuarine marine fish and macroinvertebrates that are moving inland to mainland marshes.

5.3.1.2. Open Bays

The existing open bay environments expand through time at the expense of salt marsh habitats on the bay's north side. They are less open than under no-action. There is no change in their physiography compared to present. There may be a <3 ppt decrease in salinity at the southern margins of Timbalier Bay and in the Bay Long- Bastion Bay area. No change in salinity will occur close to the Gulf margin.

In addition, new open bays form as interior marsh deterioration continues, but the wave absorbers retain the bay shoreline integrity. These bays are connected to the existing bays and have slightly lower salinity. Their depth will likely be shallower than existing bays because of fetch limitations.

Decrease in open water acreage with Alternative 1, and the relatively minor changes in other habitat types (Table 5-3), will probably mean little to the local fauna as compared to the no-action alternative. Those habitats that lost acreage, and presumably a carrying capacity for the animals that used that particular habitat, will not gain any capacity under Alternative 1 in comparison to the no-action scenario.

5.3.1.3. Salt Marsh

Within the salt marsh zone, many areas are already fragmented in 1990 (e.g., Leeville to Fourchon area, marshes north of Lake Barre). They appear to make the transition to large open water areas by the 100-year projection, but remain separate from existing bays as described above. Salt marsh areas are fragmented by the 30-year projection. Those that remain at the 100-year projection are all fragmented. Fragmentation is similar to the no-action scenarios. The trends are:

- * fragmentation/interspersation - increases
- * depth - increases (to 30 cm (11.8 inches) in new small ponds, to <2 meters (6.6 feet) in bays)
- * connectivity - increases within marsh as areas become fragmented but not openly connected with bay.

Alternative 1 will result in a net increase in acreage of saline marsh, (i.e. not permitted to erode to open water) in comparison to the no-action alternative. Important implications for local fauna will be:

- * increase in habitat available for many species of saline marsh residents, such as killifishes and gobies, that are important food items for many larger vertebrates (fish and birds) and invertebrates (blue crabs).
- * increase in habitat available for many estuarine-marine transitory migrants, i.e. penaeid shrimp, blue crabs, spotted seatrout, red drum that use saline marsh as feeding and refuge areas during their first year of life.

- * increase in important foraging habitat for many wading birds, seabirds, and certain ducks.

Alternative 1 includes construction of a set of hard-material wave absorbers placed along the margin of selected regions of saline marsh in Caillou Bay, Terrebonne Bay, Timbalier Bay, and Barataria Bay. Important implications for local fauna will be:

- * the northcentral Gulf of Mexico has limited complex hard-bottom habitat so the wave absorbers will provide attachment potential for benthic invertebrates, as well as habitat heterogeneity for small species of both invertebrates and vertebrates.

- * wave absorbers will shield the saline marsh-open water interface that has been shown to be a particularly important nursery habitat for many of the estuarine-marine animals living in the coastal waters during their first year of life.

5.3.1.4. Brackish Marsh

By 1990, much of the brackish marsh zone had degraded to large open water areas (e.g. Montegut, Madison, Wonder Lake area). The remaining brackish marsh areas increase in fragmentation. They do not, however become connected to the bays as under no-action. Trends are similar to no-action. The trends are:

- * fragmentation/interspersation - increases

- * depth - increases to 30 cm (11.8 inches) in new ponds and 1 meter (3.3 feet) in larger ponds (not bays)

- * connectivity - increases but not direct

5.3.2. Alternative 2

5.3.2.1. Barrier Islands

Rebuilding barrier islands will increase dune area, beach and marsh habitats as described in Section 5.1. There will be no change in salinity, with the exception of a seasonal decrease up to 3 ppt on the backside of the barrier shoreline. The trends are:

- * fragmentation/interspersion - reduced as inlets are closed and newly created back barrier marsh likely include fewer channels and ponds than exists currently
- * depth - similar to present
- * connectivity - reduced due to nature of created marsh and closing of some inlets.

The barrier island ecosystem will still be functioning in the study area. The system will not be gone in the Terrebonne and Timbalier basins or badly deteriorated in the Barataria basin as predicted in the no-action alternative. Important implications for local fauna will be:

- * high-energy beach habitat will serve as mating, pupping and nursery grounds for several species of sharks presently under a management plan designed to remedy a decline in population.
- * high-energy beach habitat will serve as nursery area for species such as Florida pompano and Gulf Kingfish, that have no alternative nursery habitat.
- * beach and dune habitat will serve as nesting area for many species of shore and sea birds.
- * scrub and wooded areas will serve as important stop over habitats for migrating songbirds (and other trans-Gulf migrators), as well as nesting habitat for herons, egret and other species requiring support structures for nests.
- * barrier island marsh will serve as the initial nursery for many species of young-of-the-year estuarine marine fish and macroinvertebrates that are moving inland to mainland marshes.

5.3.2.2. Open Bays

The existing open bay environments expand through time at the expense of salt marsh habitats on the bay's north side. They are less open than under no-action. There is no change in their physiography compared to present. There may be a <3 ppt decrease in salinity at the southern margins of Timbalier Bay and in the Bay Long- Bastion Bay area. No change in salinity will occur close to the Gulf margin.

The decrease in open water resulting from Alternative 2 and the relatively minor acreage changes in other habitat types (Table 5-4) will have little impact on local fauna. The faunal groups that "lost-out" in the no-action alternative as discussed in Step H (LADNR 1998h.i) will fare no better under Alternative 2 in these habitats.

5.3.2.3. Salt Marsh

Within the salt marsh zone, many areas are already fragmented in present conditions (e.g., Leeville to Fourchon area, marshes north of Lake Barre). They appear to make the transition to large open water areas by the 100-year projection, but remain separate from existing bays as described above. Salt marsh areas are fragmented by the 30-year projection. Those that remain at the 100-year projection are all fragmented. Fragmentation is similar to the no-action scenarios. The trends are:

- * fragmentation/interspersation - increases
- * depth - increases (to 30 cm (11.8 inches) in new small ponds, to <2 meters (6.6 feet) in bays)
- * connectivity - increases within marsh as areas become fragmented but not openly connected with bay.

Alternative 2 will result in a net increase in acreage of saline marsh, (i.e. not permitted to erode to open water) in comparison to the no-action alternative. Important implications for local fauna will be:

- * increase in habitat available for many species of saline marsh residents, such as killifishes and gobies, that are important food items for many larger vertebrates (fish and birds) and invertebrates (blue crabs).
- * increase in habitat available for many estuarine-marine transitory migrants, i.e. penaeid shrimp, blue crabs, spotted seatrout, red drum that use saline marsh as feeding and refuge areas during their first year of life.
- * increase in important nesting habitat for many wading birds, seabirds, and certain ducks.

Alternative 2 will result in acreage of saline marsh being "salvaged" (i.e. not permitted to erode to open water) in comparison to the no-action alternative. Important implications for local fauna will be:

- * increase in habitat available for many species of saline marsh residents that are important food items for many larger vertebrates (fish and birds) and invertebrates (blue crabs).
- * increase in habitat available for many estuarine-marine transitory migrants that use saline marsh as feeding and refuge areas during their first year of life.
- * some increase in important foraging habitat for many wading birds, seabirds, and certain ducks.

5.3.2.4. Brackish Marsh

Much of the brackish marsh zone has already degraded to large open water areas by 1990 (e.g. Montegut, Madison, Wonder Lake area). The remaining brackish marsh areas increase in fragmentation but do not become connected to the bays as under no-action. Trends are similar to no-action. The trends are:

- * fragmentation/interspersion - increases

- * depth - increases to 30 cm (11.8 inches) in new ponds and 1 meter (3.3 feet) in larger ponds (not bays)
- * connectivity - increases but not direct

5.4. Summary of Environmental Benefits

As stated in Section 5.1, the construction of Alternative 1 would prevent the loss of 5,525 hectares (21.3 mi²) of bay shoreline marsh in 30 years and 15,944 hectares (61.6 mi²) in 100 years. In addition, Alternative 1 would create 6,349 hectares (24.5 mi²) of wetlands on the islands themselves. For Alternative 2 the loss prevented is 413 hectares (1.6 mi²) in 30 years and 8,955 hectares (34.6 mi²) in 100 years, while the wetlands created on the islands covers 4,007 hectares (15.5 mi²). The majority of the land loss prevented and created as a result of Alternatives 1 and 2 are saline marsh and shore/flat habitat.

These changes in landscape will produce changes in salinity patterns within the bay marsh systems. However, none of these changes are considered to be of sufficient magnitude to result in habitat shifts in the emergent marsh areas. Similarly, for the faunal communities, most of the changes in habitat are associated with the amount of habitat of a certain type (e.g., shoreface habitat for sharks, or marsh surface habitat for killifish) rather than a change in habitat type. Importantly, the retention of some of these habitats, such as shoreface, through construction of either of the alternatives, may be critical in relation to the no-action scenarios, when great loss of these habitats is projected to occur.

6.0. ECONOMIC RESOURCES

This section quantifies several major economic impacts of potential Phase 1 Study Area project alternatives compared to no-action. The driving force of these economic impacts will be the changes in hydrologic conditions associated with barrier island and wetlands losses. The estimation procedure is to select those potential impacts that are both important and quantifiable, and are physically tied to the storm and wave related changes that would result from barrier island and wetlands losses. The procedure is to compare future without project conditions and their economic implications, with the future with project conditions.

The economic impacts analyzed in this report are limited to those which are both likely to be important in magnitude and that are quantifiable given existing data and estimation methodologies. These economic impacts are a result of changes in coastal flooding regimes that may be altered by the project scenarios. These impacts are largely increases in costs associated with residing and operating businesses in flood prone coastal areas and with losses to recreational activity and the commercial fishing industry. Flooding scenarios under two types of Category 5 hurricanes will be used, along with flood damage functions to estimate the damages of storms for the three project conditions.

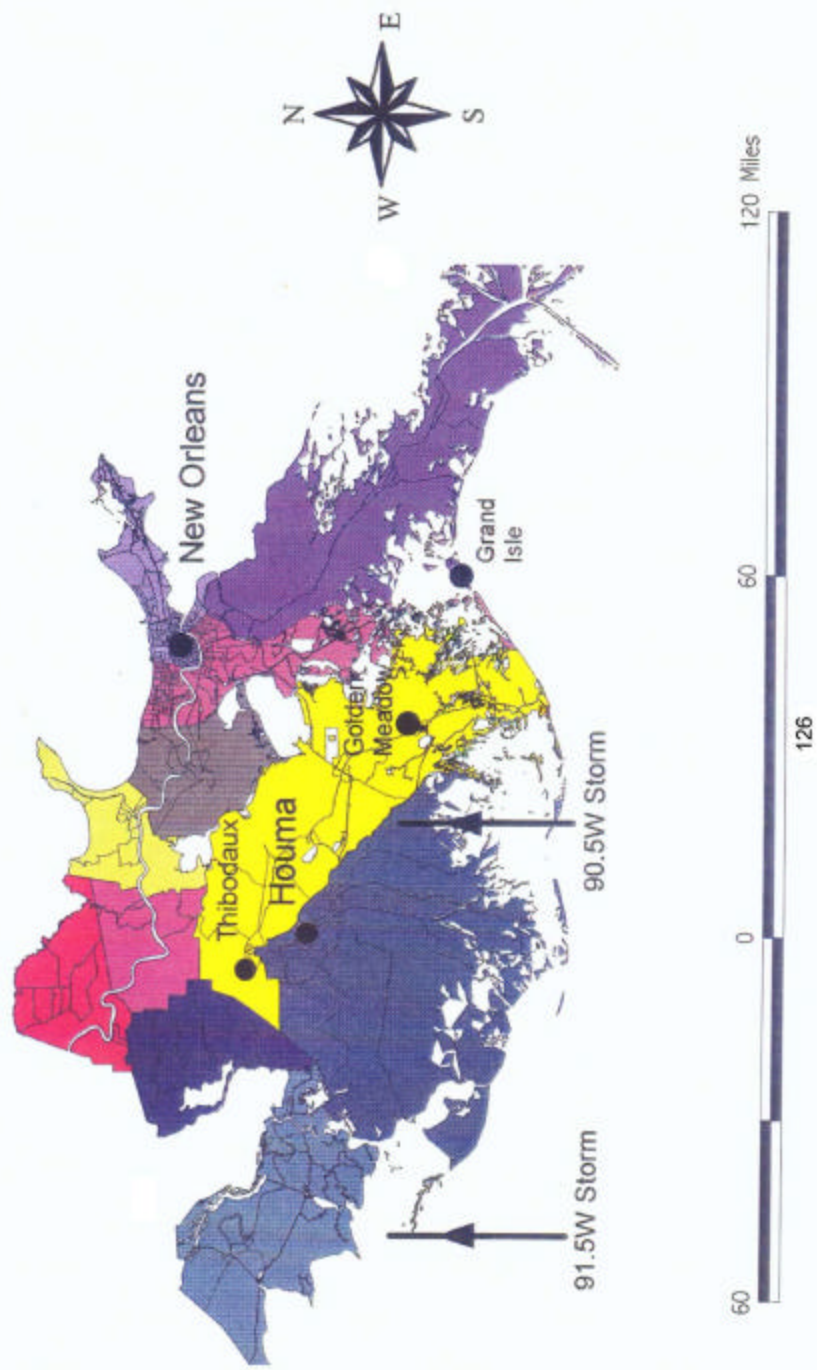
A complicating factor in analyzing economic impacts is the possible alteration of coastal population patterns under the three different project conditions. In principle, any increase in the likelihood or intensity of coastal flooding would adversely alter economic conditions in the coastal region. This would result in increases in the cost of living and doing business in coastal flood-prone areas. The effect may be to cause some people to reconsider coastal residence and business activity. One counteracting factor to any regional decline, however, would be broader economic development conditions in the state and region as a whole. These conditions may counteract any coastal out-migration. This study assumes that coastal populations will remain fixed at current levels. This may

be a reasonable assumption, as population stability has marked coastal Louisiana during the past decade (LADNR 1998f).

This report limits flood related damage and wetlands loss estimates to the study area defined for the barrier island project analysis. This area is limited to all or parts of an eleven-parish region in coastal Louisiana. The eleven parishes are: Ascension, Assumption, Jefferson, Lafourche, Orleans, Plaquemines, St. Charles, St. James, St. John, St. Mary and Terrebonne. These eleven parishes are shown in Figure 6-1. Flood damage analysis is performed at the Census Tract level. This level of resolution is dictated by the demographic and flood-depth resolutions.

In Section 6.1, a correlation between wetlands related loss is used to quantify impacts on the recreational and commercial fishing industries. Section 6.2 of this report outlines the hydrologic data used for deriving flooding conditions. Flood scenario data are coupled with US Army Corps of Engineer (USACE) flood damage data, which estimates total flood damages to residential and commercial properties from floods of varying depths. Section 6.1 explains these data and how they will be used in this report. Sections 6.3 and 6.4 present the prototype storm related flood damage estimates and analyses how these damages are expected to differ across the three project conditions. Section 6.5 is a summary of benefits of project Alternatives 1 and 2 compared to no-action.

Figure 6-1. The Eleven Parish Study Area



6.1. Wetlands And Marsh Losses

Wetland losses in the study area were estimated by the project team using historic loss rates projected to 30- and 100-years. The procedure is explained in the Step G Report (LADNR 1998g). The total acres of interior fresh, intermediate, brackish and saline marsh in the study area in 1990 was estimated to be 366,113 hectares (904,681 acres). The projected interior marsh area in 30-years under no-action at historic loss rates was estimated to be 307,482 hectares (759,802 acres), a loss of 16.0% of the 1990 wetlands acreage; and in 100-years only 231,373 hectares (571,733 acres), a loss of 36.8% of 1990 wetlands acreage. These represent losses of 58,630 hectares (144,877 acres) over the first 30-years under no-action, or 1,954 hectares (4,828 acres) per year; and an additional loss of 76,109 hectares (188,069 acres), or 1,087 hectares (2,686 acres) per year, over the remaining 70 years. Table 6-1 shows these annual wetlands losses for the no-action scenario.

The project alternatives alter these wetland losses. For example, under Alternative 1, the projected interior marsh area in 30-years is 311,095 hectares (768,729 acres), a savings of 3,613 hectares (8,928 acres) of interior wetlands compared to no-action (LADNR 1998g). Alternative 1 implies an annual wetlands loss of only 1,834 hectares (4,532 acres) per year, compared to 1,954 per year under no-action, as shown in Table 6-1. Over the remaining 30- to 100-year period, it is estimated that Alternative 1 will result in a total interior wetlands loss of only 71,586 hectares (176,892 acres), or an annual loss over that period of 1,023 hectares (2,528 acres) per year (LADNR 1998g). Table 6-1 shows these annual loss rates under the Alternatives for the two periods.

Under Alternative 1, interior wetlands will be 239,509 hectares (591,837 acres) in 100-years, compared to 1990 acreage of 366,113 hectares (904,681 acres), a reduction of 34.6%. This compares to a 36.8% loss under no-action. Alternative 2 would result in 234,956 hectares (580,587 acres) in 100-years, a reduction of 35.8% compared to 1990 wetlands acreage.

Table 6-1. Estimated Annual Interior Wetlands Losses under Project Alternatives and for No-action, 30-, and 100-Years*

Scenario	Total Interior Wetlands in 30-Years	Annual Loss Rate Over 0-30-year Period	Total Interior Wetlands in 100-years	Annual Loss Rate Over 30-100-year Period
No-action	307,482 ha	1,954 ha/yr	231,373 ha	1,087 ha/yr
Alternative 1	311,095 ha	1,834 ha/yr	239,509 ha	1,023 ha/yr
Alternative 2	307,798 ha	1,944 ha/yr	234,956 ha	1,041 ha/yr

* Acreage does not include marsh created on the barrier islands

1 hectare = 2.47 acres

Under Alternative 1, interior wetland acreage will be 239,509 hectares (591,837 acres) in 100-years, compared to 1990 acreage of 366,113 hectares (904,681 acres), a reduction of 34.6%. This compares to a 36.8% loss under no-action. Alternative 2 would result in 234,956 hectares (580,587 acres) in 100-years, a reduction of 35.8% compared to 1990 wetlands acreage.

In addition to reducing interior wetlands loss rates, Alternatives 1 and 2 will actually create new barrier island ecosystems. For example, Alternative 1 will create 4,990 hectares (12,331 acres) of new saline marsh within the barrier island system. Alternative 2 creates 2,637 hectares (6,516 acres) of saline marsh. Beach and Vegetated Dunes are also created under these Alternatives, as shown in Table 6-2.

Table 6-2. New Barrier Island Ecosystems Created by Project Alternatives

Ecosystem	Alternative 1	Alternative 2
Saline Marsh	4,990 ha	2,637 ha
Beach	967 ha	977 ha
Vegetated Dune	391 ha	394 ha

1 hectare = 2.47 acres

We can estimate and compare the economic value of interior wetlands saved and barrier island saline marsh created under the project alternatives. Wetland losses will result in reduced catch to commercial and recreational fishing due to reductions in habitat

and nutrient sources. For the economic section of this report, the simple assumption is made that stocks of commercial and recreational species diminish in proportion to wetlands area in the study area. Reduced commercial catch will lower profits, and reduced recreational catch will lower fishing enjoyment. The economic implications of these two effects can be measured. Effects of wetland habitat and nutrient losses will alter fish species composition. The Step H report suggests possible faunal impacts, although these effects are not quantified in a manner useful for estimation of economic losses (LADNR 1998h.i).

6.1.1. Commercial Fishery Losses

In order to estimate the impact on commercial fishing incomes, we make the simplistic assumption that fishing effort will remain constant in spite of reduced stock. (While effort would likely diminish, there is no way of estimating that.) The loss of catch is then the result of reduced catch for the same effort, and can be estimated using the marginal product of wetlands for commercial fishery harvest. Farber and Costanza (1987) have made such estimates for coastal Louisiana, and Bell (1989) has made estimates for coastal Florida. These studies estimate the present value of the marginal product of wetlands for commercial catch to be approximately \$91 to \$128 per hectare (\$37 to \$52 per acre) in 1990 dollars. Inflating this estimate to 1995 dollars using the Consumer Price Index results in a present value of \$102.55 to \$144.06 per hectare (\$41.51 to \$58.32 per acre). This means, for example, that losing one-hectare of wetlands, say, ten years from the present will result in a value loss at that time of \$102.55 to \$144.06 per hectare. The present value of that loss requires discounting the \$102.55 or \$144.06 per hectare over the ten-year period.

Recall that annual wetlands losses under no-action will be 1,954 hectare (4,828 acres) per year for the first 30-years, and 1,087 hectares (2,686 acres) per year for the remaining 70-years. The economic value of these losses is obtained by first calculating the value of wetlands losses in each of the 100-years, using the different loss rates for the 30- and 70-year periods. This stream of economic losses is then discounted using the

various discount rates employed in this study. The present values of these commercial fisheries losses over the 30- and 100-year periods are shown Table 6-3. Several discount rates are used, including the 8.25% discount rate mandated for US Army Corps of Engineers water projects (US Army Corps of Engineers, 1994) in 1993. For example, under no-action and the 8.25% discount rate, commercial fisheries losses attributable to loss of interior wetlands range from \$2.204 million to \$3.096 million over the 30-year period. Annualized losses over this 30-year period range from \$0.182 to \$0.256 million per year. The 5% and 3% discount rates generate present value loss estimates over the 100-year period ranging from \$3.556 million to \$7.343 million. Losses under Alternatives 1 and 2 are also shown in Table 6-3.

Table 6-4 summarizes the cost savings, or reductions in commercial fisheries losses under the two alternatives. For example, consider loss reductions under Alternative 1 compared to no-action. Table 6-3 shows that the low estimated present value of commercial fisheries losses over the 30-year period under no-action was \$2.204 million, using the 8.25% discount rate. Comparable fisheries losses under Alternative 1 were \$2.068 million. Hence, there was a reduction of \$0.136 million in losses under Alternative 1 compared to no-action. This value is shown in column 5 of Table 6-4 below. This value represents the present value of commercial fishery benefits for Alternative 1 compared to no-action over the 30-year period. Table 6-4 shows that loss reductions, or benefits, over the 30-year period of Alternative 1 compared to no-action range from \$0.136 to \$0.339 million, depending on the discount rates used for present value calculations. The annualized values over this period range from \$0.011 to \$0.016 million per year.

Table 6-3. Present and Annualized Values of Commercial Fishery Losses Due to Wetlands Loss Under No-action and Project Alternatives (\$ millions)

Base Condition	Compared to:	Period (Years)	Low/High	8.25% Present Value	Annualized Value	5.00% Present Value	Annualized Value	3.00% Present Value	Annualized Value
Current Condition	No-action	30	Low	\$2.204	\$0.182	\$3.080	\$0.155	\$3.928	\$0.124
			High	\$3.096	\$0.255	\$4.327	\$0.218	\$5.517	\$0.175
		100	Low	\$2.319	\$0.191	\$3.555	\$0.179	\$5.220	\$0.165
			High	\$3.258	\$0.269	\$4.994	\$0.252	\$7.334	\$0.232
Current Condition	Alternative 1	30	Low	\$2.068	\$0.171	\$2.891	\$0.146	\$3.686	\$0.117
			High	\$2.906	\$0.240	\$4.061	\$0.205	\$5.179	\$0.164
		100	Low	\$2.177	\$0.180	\$3.338	\$0.168	\$4.903	\$0.155
			High	\$3.058	\$0.252	\$4.689	\$0.236	\$6.888	\$0.218
Current Condition	Alternative 2	30	Low	\$2.192	\$0.181	\$3.065	\$0.154	\$3.907	\$0.124
			High	\$3.080	\$0.254	\$4.305	\$0.217	\$5.489	\$0.174
		100	Low	\$2.303	\$0.190	\$3.519	\$0.177	\$5.146	\$0.163
			High	\$3.235	\$0.267	\$4.943	\$0.249	\$7.229	\$0.229

Table 6-4 shows that the estimated loss reductions, or benefits, of Alternative 2 compared to no-action range from a present value of \$0.011 to \$0.028 million for the 30-year period, depending on discount rates. Table 6-4 also shows loss reductions, or benefits, of the Alternatives are greater for the 100-year than the 30-year period, as expected.

Table 6-4. Present and Annualized Values of Reductions in Commercial Fishery Losses Attributable to Project Alternatives (\$ millions)

Losses MINUS Under Losses Under	Period (Years)	Low/High	8.25% Present Value	Annualized Value	5.00% Present Value	Annualized Value	3.00% Present Value	Annualized Value
No-action Alternative 1	30	Low	\$0.136	\$0.011	\$0.189	\$0.010	\$0.241	\$0.008
		High	\$0.190	\$0.016	\$0.266	\$0.013	\$0.339	\$0.011
	100	Low	\$0.142	\$0.012	\$0.217	\$0.011	\$0.317	\$0.010
		High	\$0.200	\$0.016	\$0.305	\$0.015	\$0.446	\$0.014
No-action Alternative 2	30	Low	\$0.011	\$0.001	\$0.016	\$0.001	\$0.020	\$0.001
		High	\$0.016	\$0.001	\$0.022	\$0.001	\$0.028	\$0.001
	100	Low	\$0.016	\$0.001	\$0.036	\$0.002	\$0.075	\$0.002
		High	\$0.023	\$0.002	\$0.050	\$0.003	\$0.105	\$0.003

In addition to reducing interior wetland losses, the project Alternatives will result in new barrier island salt marsh. Table 6-2 shows that Alternative 1 will create 4,982 hectares (12,311 acres) of new salt marsh, and Alternative 2 will create 2,637 hectares (6,516 acres). The assumption is that the newly created marsh will gradually become fully productive within 10 years of project initiation. We also assume its functionality will increase linearly over that period, so Alternative 1 will add 498 effective hectares (1,231 acres) of marsh per year over the 10 year period, and Alternative 2 will add 264 hectares (652 acres) per year over that period.

We can use the estimated \$102.54 to \$144.06 per hectare (\$41.51 to \$58.32 per acre) commercial fishery marginal productivity values described above to estimate the value of this new salt marsh. Table 6-5 shows the present and annualized values of the gains to commercial fisheries from new salt marsh. For example, under Alternative 1, 498 hectares (1,231 acres) are created per year for each of 10 years. When the marginal product of an acre of marsh is valued at \$102.54 per hectare, the present value of this gain is estimated to be \$0.339 million, using the 8.25% discount rate, as shown in column 4 of Table 6-5. The annualized value of this gain, when annualized over a project period of 30-years, is \$0.031 million per year. Using the high value of marginal productivity, \$144.06 per hectare, the present value of Alternative 1 new marsh creation is \$0.476 million. The present values are the same whether a 30 or 100-year period of analysis is used, since the gains will be fully experienced within 10-years, by assumption. However, the annualized values will depend upon whether the period of analysis is 30- or 100-years. Table 6-5 shows that Alternative 2 provides less commercial fisheries gains than Alternative 1; for example gains of only \$0.180 to \$0.252 million for the 30-year period using the 8.25% discount rate.

Table 6-5. Commercial Fishery Gains from New Barrier Island Salt Marsh Creation by Project Alternative (\$millions)

		8.25%		5.00%		3.00%		
	Period (Years)	Low/ High	Present Value	Annualized Value	Present Value	Annualized Value	Present Value	Annualized Value
Alternative 1	30	Low	\$0.339	\$0.031	\$0.394	\$0.026	\$0.436	\$0.022
		High	\$0.476	\$0.043	\$0.554	\$0.036	\$0.612	\$0.031
	100	Low	\$0.339	\$0.028	\$0.394	\$0.020	\$0.436	\$0.014
		High	\$0.476	\$0.039	\$0.554	\$0.028	\$0.612	\$0.019
Alternative 2	30	Low	\$0.180	\$0.016	\$0.416	\$0.027	\$0.530	\$0.027
		High	\$0.252	\$0.023	\$0.584	\$0.038	\$0.745	\$0.038
	100	Low	\$0.180	\$0.015	\$0.416	\$0.021	\$0.530	\$0.017
		High	\$0.252	\$0.021	\$0.584	\$0.029	\$0.745	\$0.024

6.1.2. Recreational Losses

Recreation will be adversely impacted by barrier island loss due to reductions in wetland habitat and nutrient flows to fisheries. A study of Louisiana recreationists by Bergstrom and Stoll (1990) measured the loss to recreationists from reduced bag and catch in wetland areas. Recreationists would value a 50% reduction in catch or bag at \$66 per year per user (1986), or \$92 in 1995. Users place a value on current conditions but would place a lower value if catch or bag conditions were less desirable.

Estimated interior wetland losses under no-action over the 100-year period were estimated to be 36.8% of the 1990 wetlands area (see above). We assume that a 37% reduction in catch or bag would be valued at $(37\%)/(50\%) = 0.74$ times \$92, or \$68.08 per year per user. We also assume that catch or bag would fall proportionally with wetland loss over time, so the \$68.08 annual loss would increase linearly from \$0 at present to \$68.08 in 100-years.

Estimated interior wetlands loss over the 100-year period under Alternative 1 was estimated in Step G to be 34.6% of 1990 acreage (see above) (LADNR 1998g). In addition, Alternative 1 would create 4,990 hectares (12,331 acres) of new barrier island saline marsh. If new marsh were simply added to the interior marsh acreage, Alternative

1 would result in a net loss of only 33.2% of original 1990 interior wetlands. Similarly, Alternative 2 would result in a loss of 35.8% of 1990 acreage; and when new barrier island saline marsh is added to the interior acreage, only a net loss of 35.1% is calculated over the 100-year period. Using the logic reflected in the no-action calculations, Alternative 1 results in an ultimate annual loss of \$60.72 per year ($33.2/50 = 0.66$ times \$92) in 100-years; and Alternative 2 results in an ultimate annual loss of \$64.40 ($35.1/50 = 0.70$ times \$92) in 100-years. A similar linearity assumption is made that these losses increase from \$0 annually to \$60.72 and \$64.40 per year, respectively, over the 100-year period.

The Bergstrom and Stoll (1990) study estimated a total of 76,000 recreational users (not total visits) annually in 1986 within the seven parish regions surrounding Terrebonne-Barataria Bays. It is not obvious whether recreational use will increase, decrease or remain the same. Usage trends will depend upon population growth in the region, recreational interest, and the quality of recreational activity in the region. If recreational use will increase over time, losses in recreational value will be higher than if use remains constant, as more people will be experiencing diminished recreational enjoyment as wetlands disappear. We make two estimates of recreational losses: 1) recreational use remains constant at 76,000; and 2) recreational use diminishes at a rate proportional to wetland loss. For example, under no-action, wetlands losses in 100-years are projected to be 36.8% (LADNR 1998g), implying annual usage will fall from 76,000 users currently to 48,032 in 100-years. Similar usage rates can be estimated for wetland losses under the two project alternatives. Usage rates under Alternative 1 will fall by 33.2% to 50,768 users annually in 100-years; and rates under Alternative 2 will fall by 35.1% to 49,324 users.

The present values of these recreational losses over the 30- and 100-year periods are shown in Table 6-6. Using the 8.25% discount rate, the present value of these recreational losses under no-action range from \$5.5 to 5.9 million for the 30-year period and from \$7.47 to \$8.20 million for the 100-year period. Losses under Alternative 1 range from \$4.99 to \$5.26 million for the 30-year period and from \$6.36 to \$6.87 million

for the 100-year period. The present values of losses are also shown for 5% and 3% discount rates. These are substantially higher than losses estimated using the 8.25% discount rate. Annualized values are also shown in Table 6-6.

Table 6-6. Present Value of Recreational Fishery Losses Due to Wetlands Loss Under Project Alternatives (\$ millions)

Base Condition	Compared to:	Period (Years)	Low/High	8.25%		5.00%		3.00%	
				Present Value	Annualized Value	Present Value	Annualized Value	Present Value	Annualized Value
Current No-action Condition		30	Low/	\$5.529	\$0.503	\$9.246	\$0.601	\$13.183	\$0.673
			High	\$5.859	\$0.533	\$9.874	\$0.642	\$14.144	\$0.722
		100	Low/	\$7.473	\$0.617	\$17.985	\$0.906	\$38.842	\$1.229
			High	\$8.204	\$0.677	\$20.779	\$1.047	\$47.159	\$1.492
Current Alternative 1 Condition		30	Low/	\$4.990	\$0.454	\$8.352	\$0.543	\$11.913	\$0.607
			High	\$5.257	\$0.478	\$8.859	\$0.576	\$12.691	\$0.648
		100	Low/	\$6.769	\$0.559	\$16.383	\$0.825	\$35.583	\$1.126
			High	\$7.361	\$0.608	\$18.645	\$0.939	\$42.316	\$1.339
Current Alternative 2 Condition		30	Low/	\$5.260	\$0.478	\$8.799	\$0.572	\$12.548	\$0.640
			High	\$5.558	\$0.505	\$9.366	\$0.609	\$13.418	\$0.685
		100	Low/	\$7.121	\$0.588	\$17.184	\$0.866	\$37.212	\$1.178
			High	\$7.782	\$0.642	\$19.712	\$0.993	\$44.738	\$1.416

Alternatives 1 and 2 result in lower recreational losses than no-action. Table 6-7 estimates these loss reductions, or benefits, of the alternatives compared to no-action. For example, column 5 shows these estimates using the 8.25% discount rate. Alternative 1 results in lower present values of recreational losses compared to no-action equal to \$0.54 million over the 30-year period using the low estimate of recreational losses; and using the high value for losses, these reductions are \$0.60 million. The annualized values of these savings, or benefits, of Alternative 1 compared to no-action range from \$0.077 to \$0.086 million per year over the 30-year period. The present value of loss reductions from Alternative 1 compared to no-action over the 100-year period range from \$0.704 to \$0.843 million; and annualized savings range from \$0.058 to \$0.069 million per year. Of course, the estimated present values of these reductions in recreational losses are higher when using smaller discount rates, as Table 6-7 illustrates.

Table 6-7. Present and Annualized Values of Reductions in Recreational Losses Attributable to Project Alternatives (\$ millions)

Losses MINUS			8.25%		5.00%		3.00%	
Under	Losses	Period	Low/	Present	Annualized	Present	Annualized	
	Under	(Years)	High	Value	Value	Value	Value	Value
No-action Alternative 1		30	Low/	\$0.539	\$0.049	\$0.894	\$0.058	\$1.270
			High	\$0.602	\$0.055	\$1.015	\$0.066	\$1.453
		100	Low/	\$0.704	\$0.058	\$1.602	\$0.081	\$3.259
			High	\$0.843	\$0.069	\$2.134	\$0.108	\$4.843
No-action Alternative 2		30	Low/	\$0.269	\$0.025	\$0.447	\$0.029	\$0.635
			High	\$0.301	\$0.028	\$0.508	\$0.033	\$0.726
		100	Low/	\$0.352	\$0.029	\$0.801	\$0.040	\$1.630
			High	\$0.422	\$0.035	\$1.067	\$0.054	\$2.421

Table 6-7 shows that the loss reductions are smaller for Alternative 2 compared to no-action than the savings from Alternative 1 compared to no-action. Alternative 1 does provide some loss savings compared to Alternative 2.

The losses in Tables 6-6 and 6-7 measure welfare losses to recreationists from reduced recreational enjoyment. They do not measure income losses to the recreational industry, nor do they estimate the reduction in recreational usage in a meaningful manner; they simply make an ad hoc proportional assumption. It has been estimated that recreational activities result in regional (Lafourche, Jefferson, Plaquemines and Terrebonne Parishes) spending of \$956.2 million annually, and employment of 18,696 persons if we include direct and indirect economic impacts (Industrial Economics 1996). Recreational visitation and spending may decline with wetlands losses over the next 100-years. However, this will be a net result of quality of recreational experience, regional population growth, and recreational interests. Estimation of these trends, and implications for regional income and employment, would require an entire study.

6.2. Hydrologic Regimes

The coastal hydrologic regimes were established by the LSU project team using computerized hydrologic modeling. Two types of hydrologic phenomena were modeled:

* storm surge flood levels under two prototype storms

* average wave height elevations under normal conditions

The procedures for modeling these two phenomena are explained in the Step G report (LADNR 1998g). Preliminary analysis of the average wave height scenarios under the three conditions showed differences that were too small for any related economic analysis. Therefore, economic analysis was limited to the storm surge flood scenarios. However, the wetlands loss impacts of project alternatives attributable to changes in wave action were monetized for this study.

Hydrologic models were used to predict storm surge elevations ranging from 0 to 6.1 m for two worst case storms: Category 5 hurricanes reaching landfall at latitudes 90.5W and 91.5W. These latitudes are shown in Figure 6-1. Topographic models were used to estimate land elevations, a complex function of sea level rise, wetland loss and coastal subsidence. The difference between predicted storm surge and topographic elevations is flood-depth from storm surge. Flood-depth is then the height of the water level above the land surface. All elevations are measured to the National Geodetic Vertical Datum (NGVD). The flood-depth is used as the basis for flood damage estimation.

Flood-depth data were created at LSU using ArcInfo(GIS software and exported in a format for use by the Spatial Analyst Extension(in ArcView(, a GIS software for personal computers. These data are in raster form, with each pixel (small square) representing a predicted flood-depth. Flood-depths were developed as continuous data but were reclassified into discrete classes for visual and statistical analysis. The reclassification scheme was as follows:

Original Depth	Reclassified Depth
> 16.5 feet (5.0 m)	17 feet (5.2 m)
15.5-16.5 feet (4.7-5.0 m)	16 feet

((
1.5-2.5 feet (0.5-0.8 m)	2 feet (0.6 m)
0.5-1.5 feet (0.2-0.5 m)	1 feet (0.3 m)
< 0.5 feet (0.2 m)	0 feet (0.0 m) - No Flooding

A baseline tidal surge estimation was made for each of the two prototype storms using the present configuration of barrier islands and coastal topography. Figure 6-2 shows these tidal surge flood-depths for the 90.5W storm. This is a complicated map but illustrates the variation in flood-depths in the study area. In order to assist the reader in understanding the resolution of the surge flood data, Figure 6-3 is a magnified version of Figure 6-2 showing the same flood data overlaid with US Bureau of the Census census tract boundaries for Terrebonne and Lafourche parishes. Census tract boundaries were obtained from Wessex(and are based on Bureau of the Census Tiger 92 files.

Each pixel of the raster flood data in Figure 6-3 has a surge flood-depth associated with it. It was necessary to obtain a statistical flood-depth for each census tract in the study area. The mean and median of the raster flood-depth data were obtained for each census tract using the "Summary Zone" feature of the ArcView Spatial Analyst Extension(. The mean and median flood-depths can differ substantially within a census tract, as there is no general rule whether one will be greater than the other in a particular tract. As explained below, damage estimates were made using each of these statistics.

For example, census tract 221090002 in Terrebonne parish is shown in Figure 6-3 as the tract with the dot representing Houma. This tract contains 29 pixels of flood-depth data. The mean flood-depth for this tract is 0.10 m with the current configuration and 90.5W storm; and the median depth is 0.0 m. Census tract 220570216 is in Lafourche parish directly to the east of Houma in Figure 6-3. This tract contains 278 pixels, with a mean flood-depth of 0.48 meters (1.6 feet) and a median depth of 0.30 meters (1.0 feet). Similar mean and median flood-depth statistics were obtained for all census tracts in the study area, for each of the two prototype storms and the three project assumptions (no-

action, Alternative 1, Alternative 2) plus the baseline current configuration condition (the basis for Figures 6-2 and 6-3).

Flood-depths were modeled under the three project conditions for 30- and 100-years from the present. The economic impact methodology is not so highly developed that it can meaningfully analyze the smaller changes likely to occur over a 30-year period. Therefore, the procedure used in this report was to analyze flooding economic impacts for 100-years from the present and to presume that impacts 30-years from the present would be only 30% of the full 100-year impact; i.e., economic impacts occur linearly over time. This may or may not be the case. Only the 100-year analyses and maps are presented in this section.

Figure 6-2. Tidal Surge Flood Depths Under Current Barrier Shoreline with 90.5W Storm.

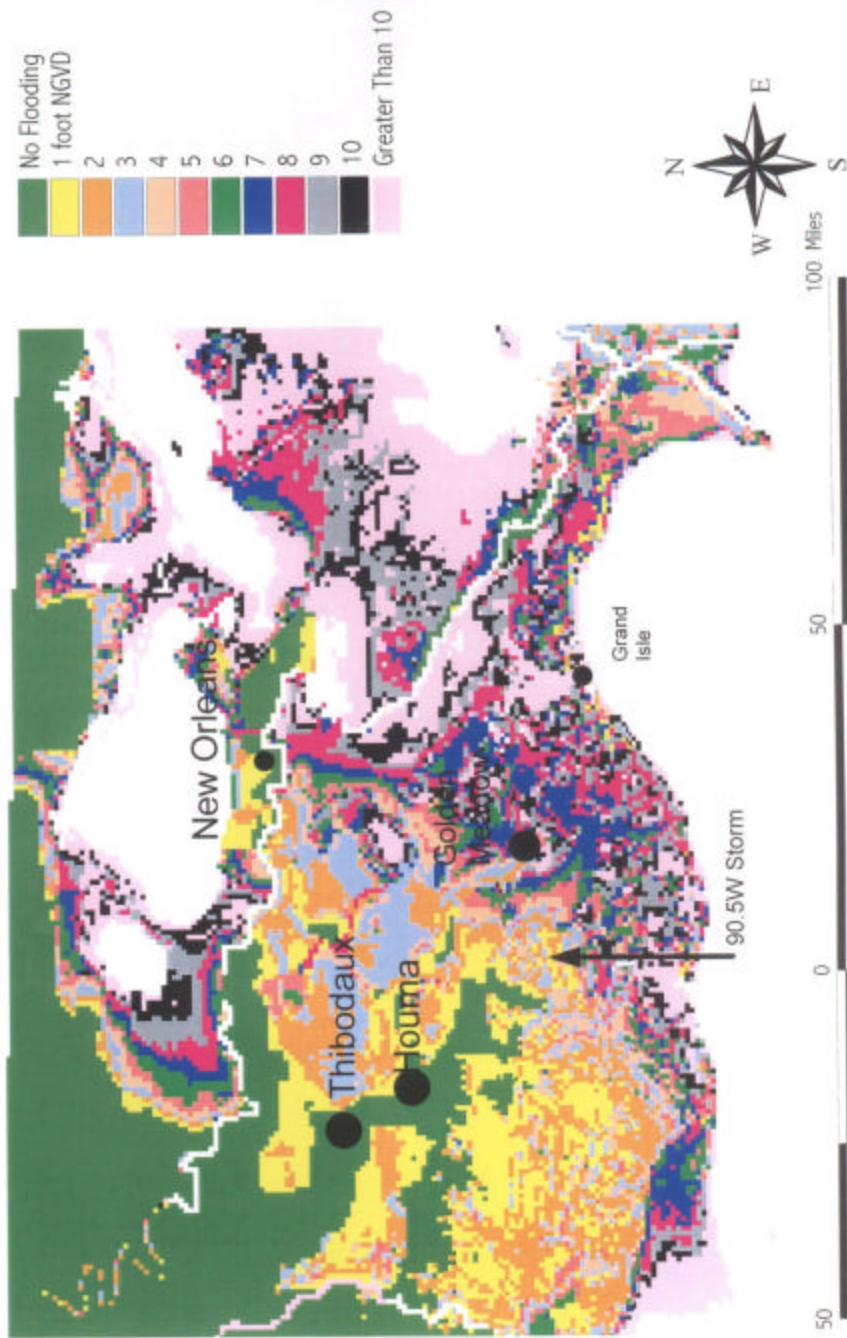
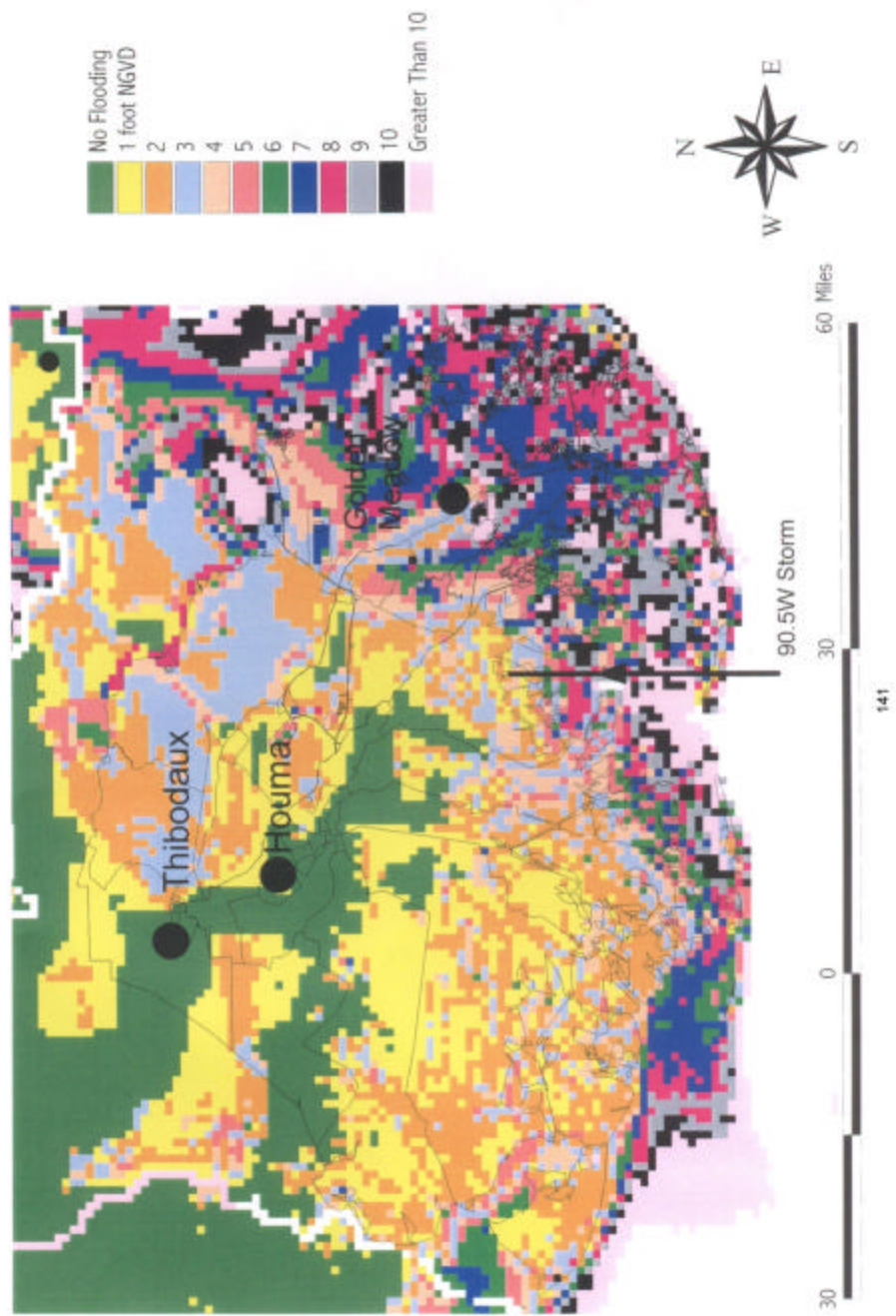


Figure 6-3. Zoom of Tidal Surge Flood Depths Under Current Barrier Shoreline with 90.5W Storm Showing Terrebonne and Lafourche Parish Census Tracts.



The effects of the different project assumptions on flood-depths can be analyzed using the GIS system employed in this study. While the purpose of this study is to investigate economic impacts of these assumptions, it is illustrative to show how one can use the flood-depth data to estimate flood-depth impacts of the project assumptions. For example, we can compare flood-depths of a 90.5W storm occurring at present with depths of the identical storm 100-years from the present under a no-action assumption; i.e., barrier islands are allowed to disintegrate. Figure 6-4 shows the pixel-by-pixel expected increases in depths under this no-action assumption for the census tracts in Terrebonne and Lafourche parishes. Census tract 221090002 in Terrebonne Parish is expected to have flood-depths increase from a mean of 0.11 meters (0.36 feet) presently to 0.17 meters (0.56 feet) in 100-years under the no-action assumption (i.e., an increase of 0.06 meters (0.20 feet)). Similarly, tract 220570216 in Lafourche parish is expected to have an increase in mean depth from 0.48 meters (1.6 feet) under present conditions to 0.87 meters (2.9 feet) in 100-years under the no-action assumption (i.e., an increase of 0.39 meters (1.3 feet)).

Figure 6-5 shows flood-depth implications for the 91.5W prototype storm comparing flood-depths after 100-years under no-action to flood-depths expected for the same storm in the present. Increased flooding under the no-action case impacts the entire study area; the majority of these increases are between 0.0 and 0.61 meters (0.0 and 1.0 feet).

Figure 6-4. Increases in Flood Depth in 100-Years Under No-Action Compared to Current Flood Depths for 90.5W Storm, Showing Terrebonne and Lafourche Parish Census Tract

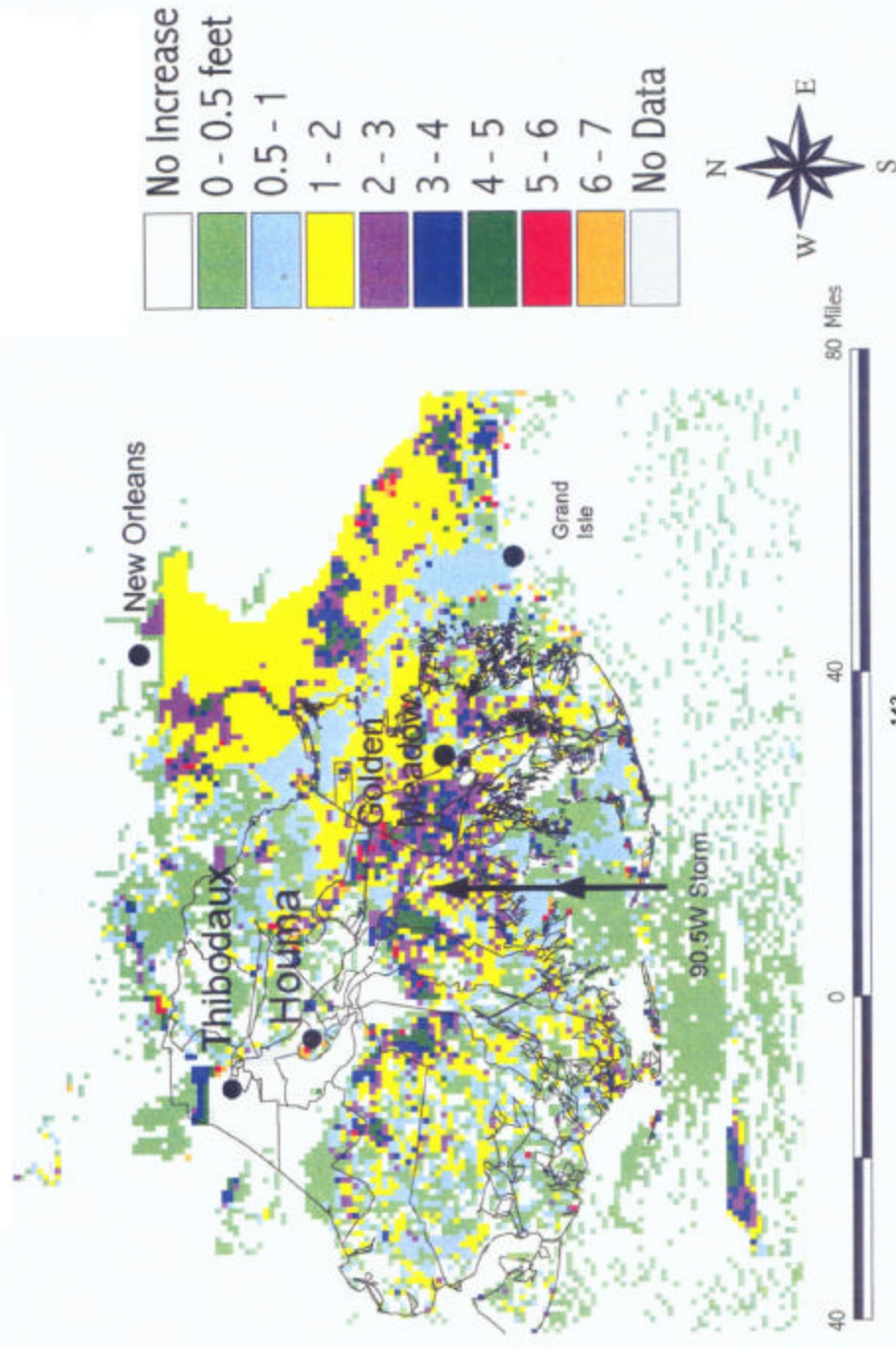
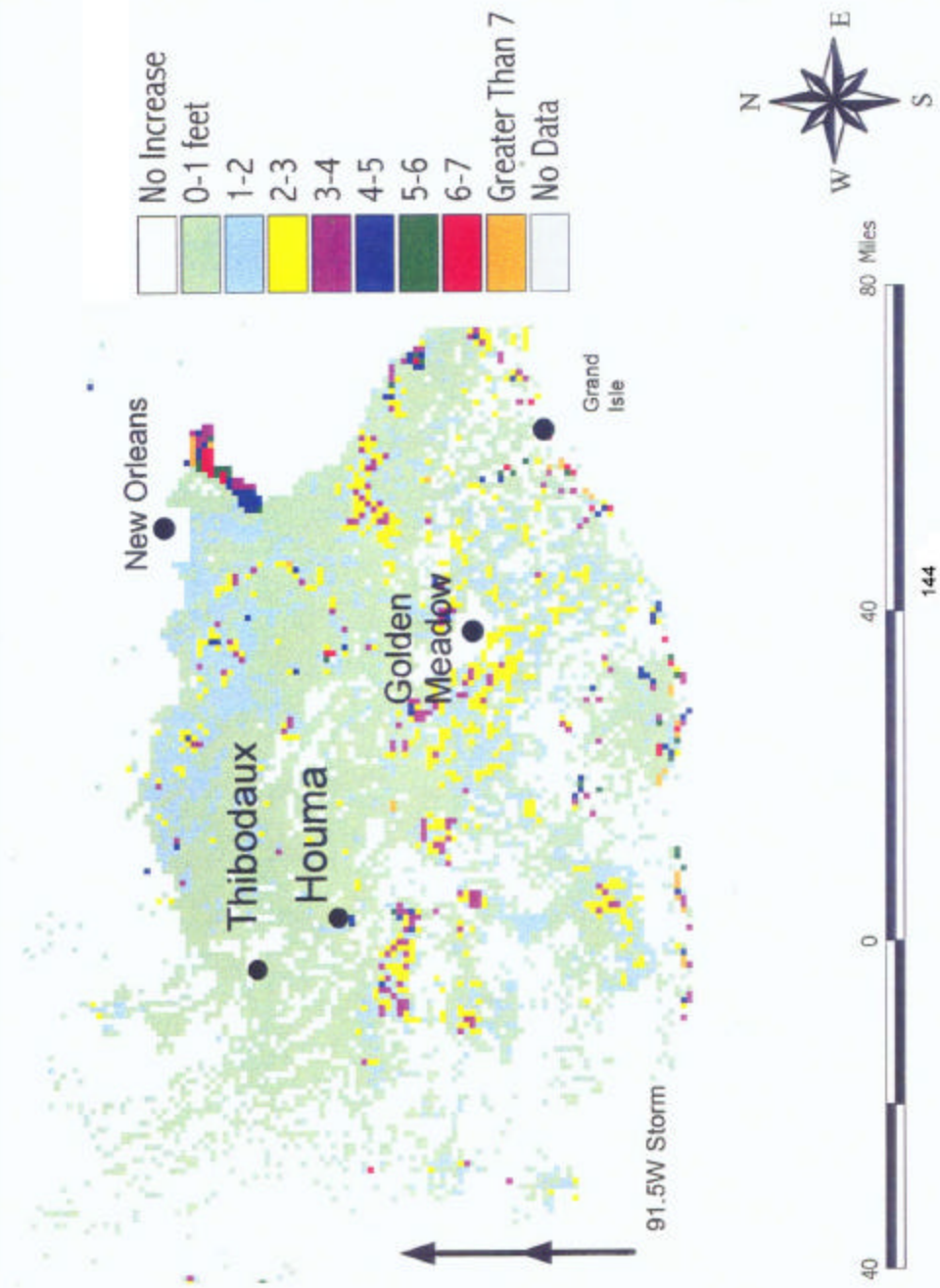


Figure 6-5. Increases in Flood Depth in 100-Years Under No-Action Compared to Current Flood Depths for 91.5W Storm



The expected flooding mitigation effects of Alternatives 1 and 2 can be illustrated for the 100-year horizon using the GIS system. Figures 6-6 and 6-7 show the increases in flood-depths from the 90.5W prototype storm for no-action compared to maintaining Alternatives 1 and 2 respectively.

It is clear from these maps that the eastern portion of the study area would experience increased flooding depths under no-action compared with the alternatives. Compared to no-action, Alternative 1 reduces flood depths by 0.9-1.5 meters (3-5 feet) in the eastern portion of the study area, while Alternative 2 reduces flooding by 0.6-0.9 meters (2-3 feet).

Figures 6-8 through 6-9 show flood-depth implications of the alternatives for the 91.5W prototype storm. The figures show a pervasive flood-depth increase across the study area after 100-years when no-action is compared to both alternatives. Compared to no-action, Alternative 1 reduces flood depths by 0.0 and 0.9 meters (0.0 and 3.0 feet), with larger reductions of 0.9 to 1.8 meters (3.0 to 6.0 feet) in the southern portion of the study area.

Some types of economic impacts of flooding are more dependent upon whether the area is flooded at all, rather than upon the elevation of the flooding. For example, road damages would be more related to whether the road is flooded than to the elevation of the water above the road surface. For this reason, Figures 6-10 and 6-11 illustrate those areas where locations not flooded currently under a 90.5W storm would likely be flooded in 100-years under the no-action plan. These are the flooding "margins." Figure 6-10 shows these margins for the 90.5W storm. Bands of newly flooded areas run across the center of the study area below Houma and run in a band between Thibodaux and Houma. Figure 6-11 shows the 91.5W storm margins consisting primarily of two bands: one southeast of New Orleans and another running along Grand Isle and Grand Terre. The flooding margins for the no-action compared to Alternatives 1 and 2 are considerably smaller than those shown in Figures 6-10 and 6-11; they are so small that this study does not estimate the costs associated with those margins.

Figure 6-6. Increases in Flood Depth of 90.5W Storm in 100-Years Under No-Action Compared to Alternative 1.

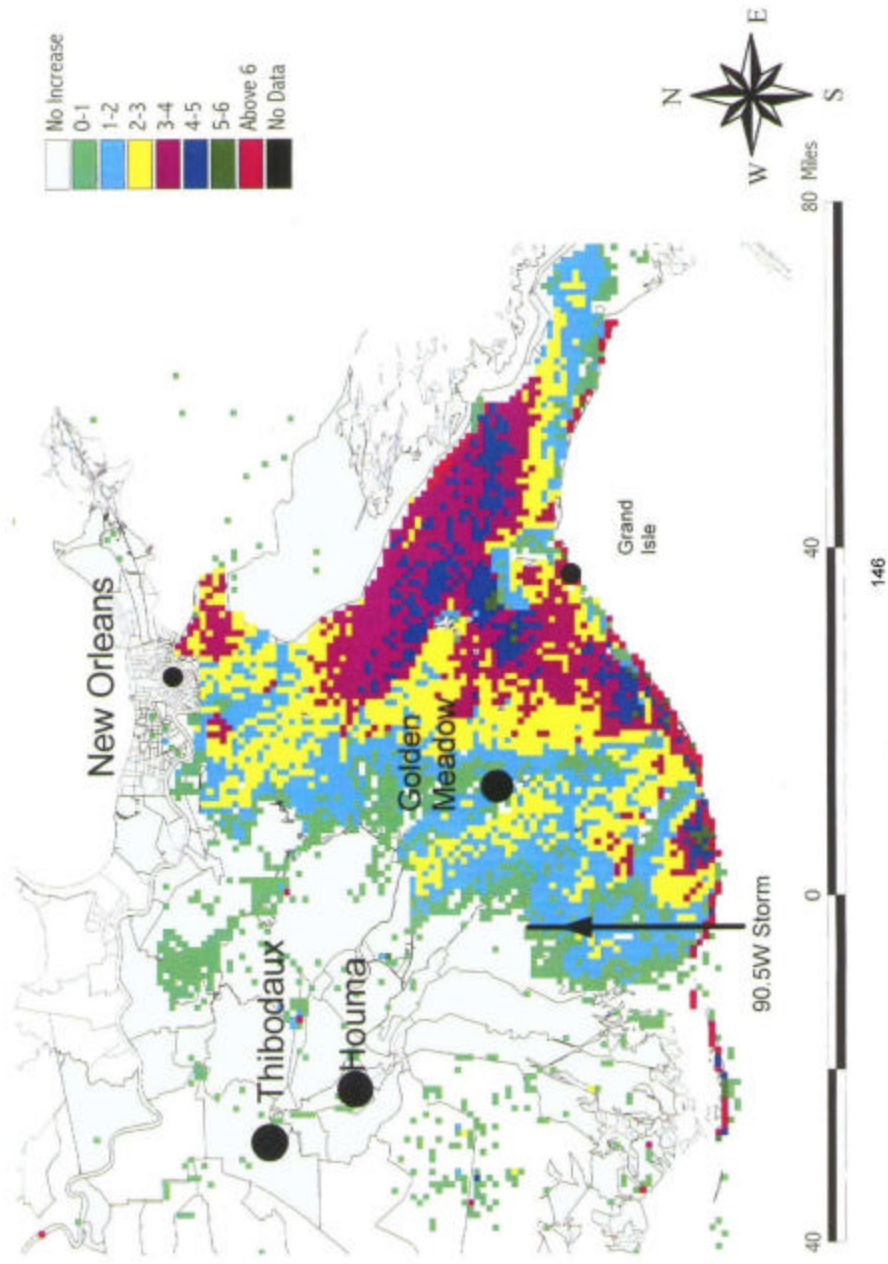


Figure 6-7. Increases in Flood Depth of 90.5W Storm in 100-Years Under No Action Compared to Alternative 2.

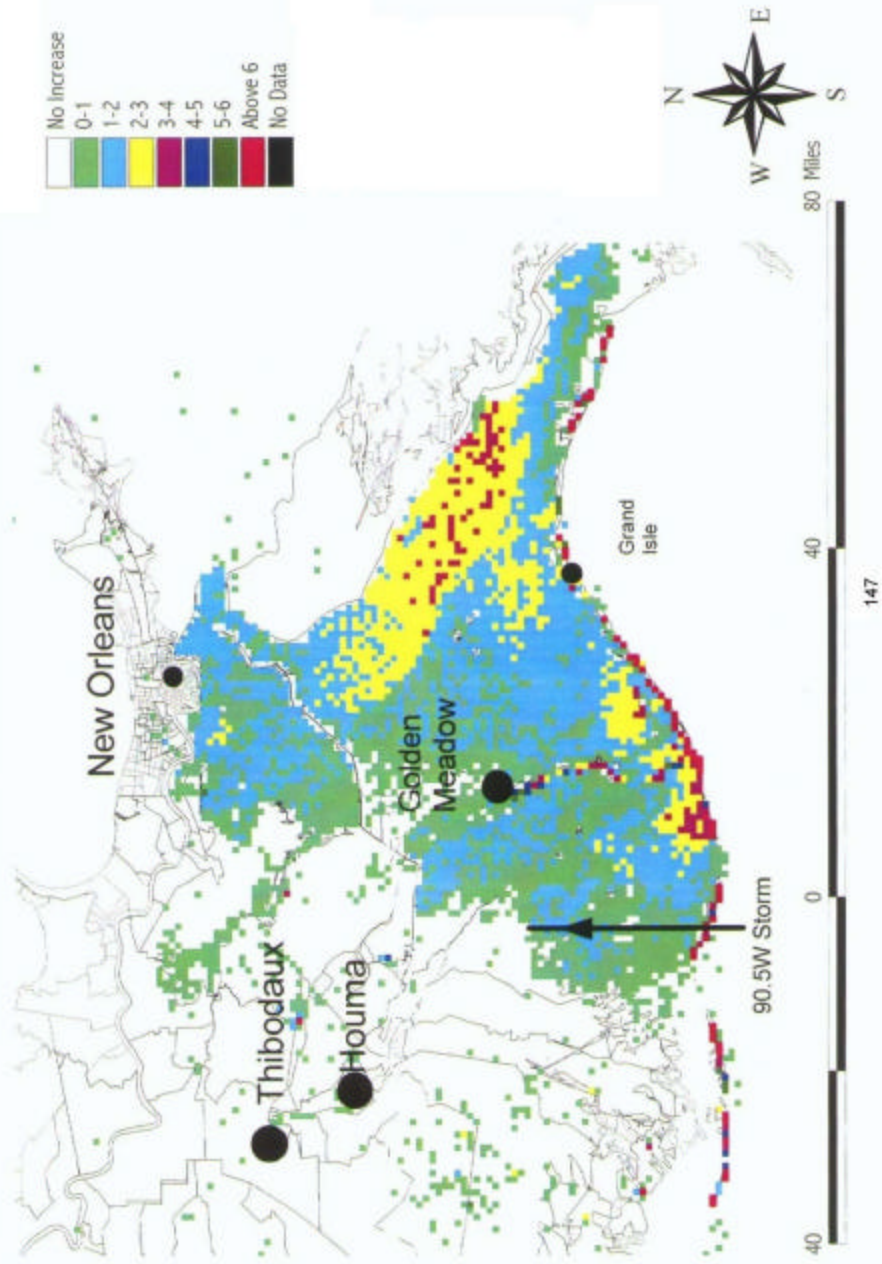


Figure 6-8. Increases in Flood Depth of 91.5W Storm in 100-Years Under No Action Compared to Alternative 1.

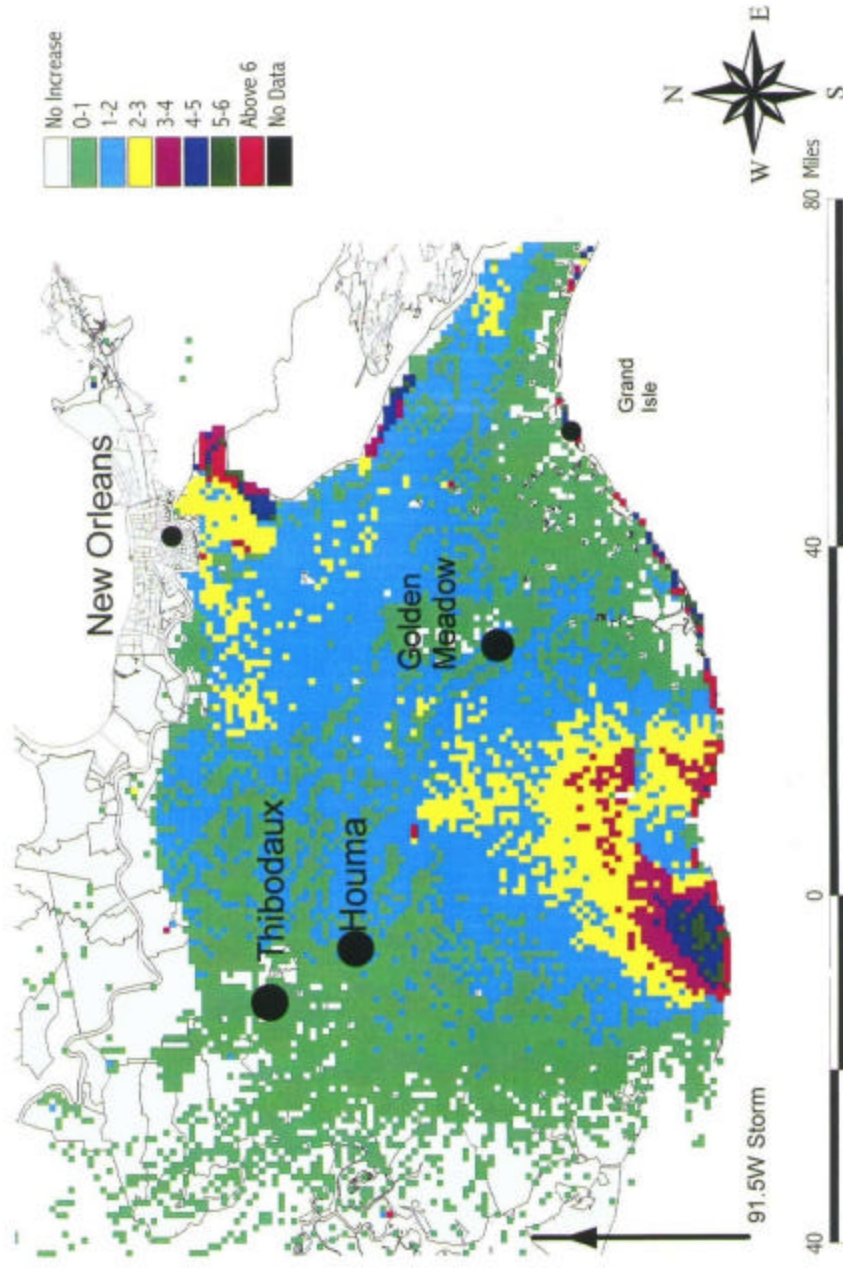


Figure 6-9. Increases in Flood Depth of 91.5W Storm in 100-Years Under No-Action Compared to Alternative 2.

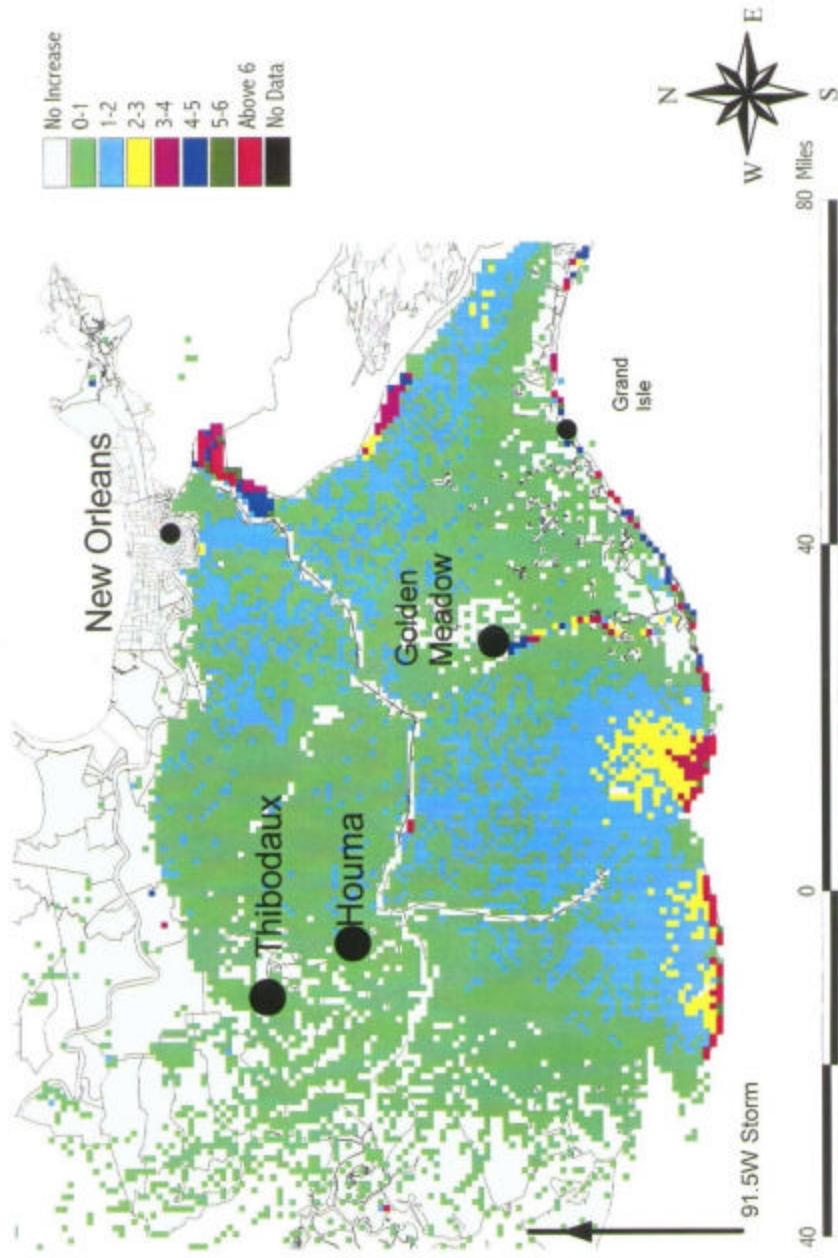


Figure 6-10. Areas Newly Flooded by 90.5W Storm in 100 Years Under No-Action
But Not Currently Flooded in 90.5W Storm.

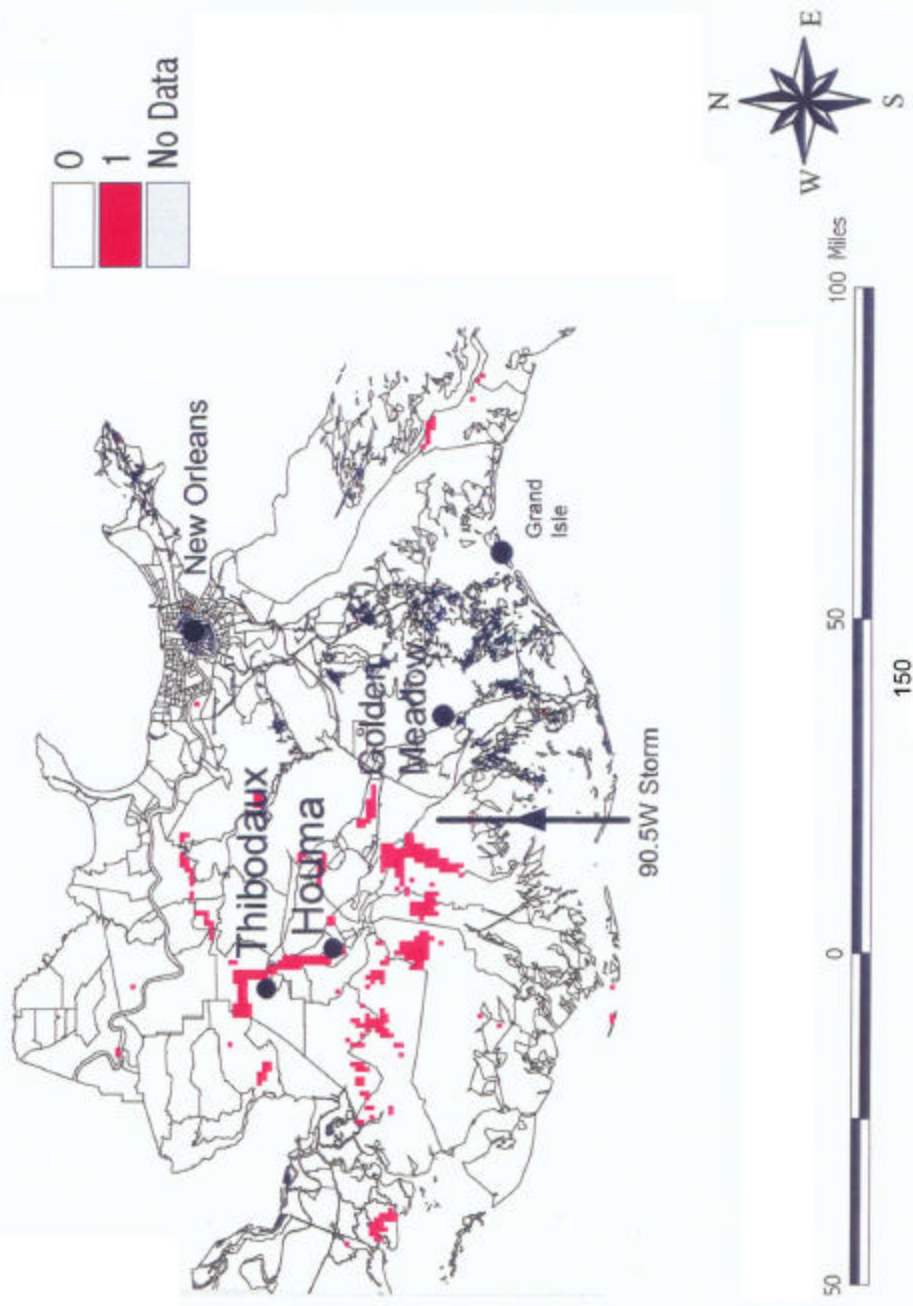
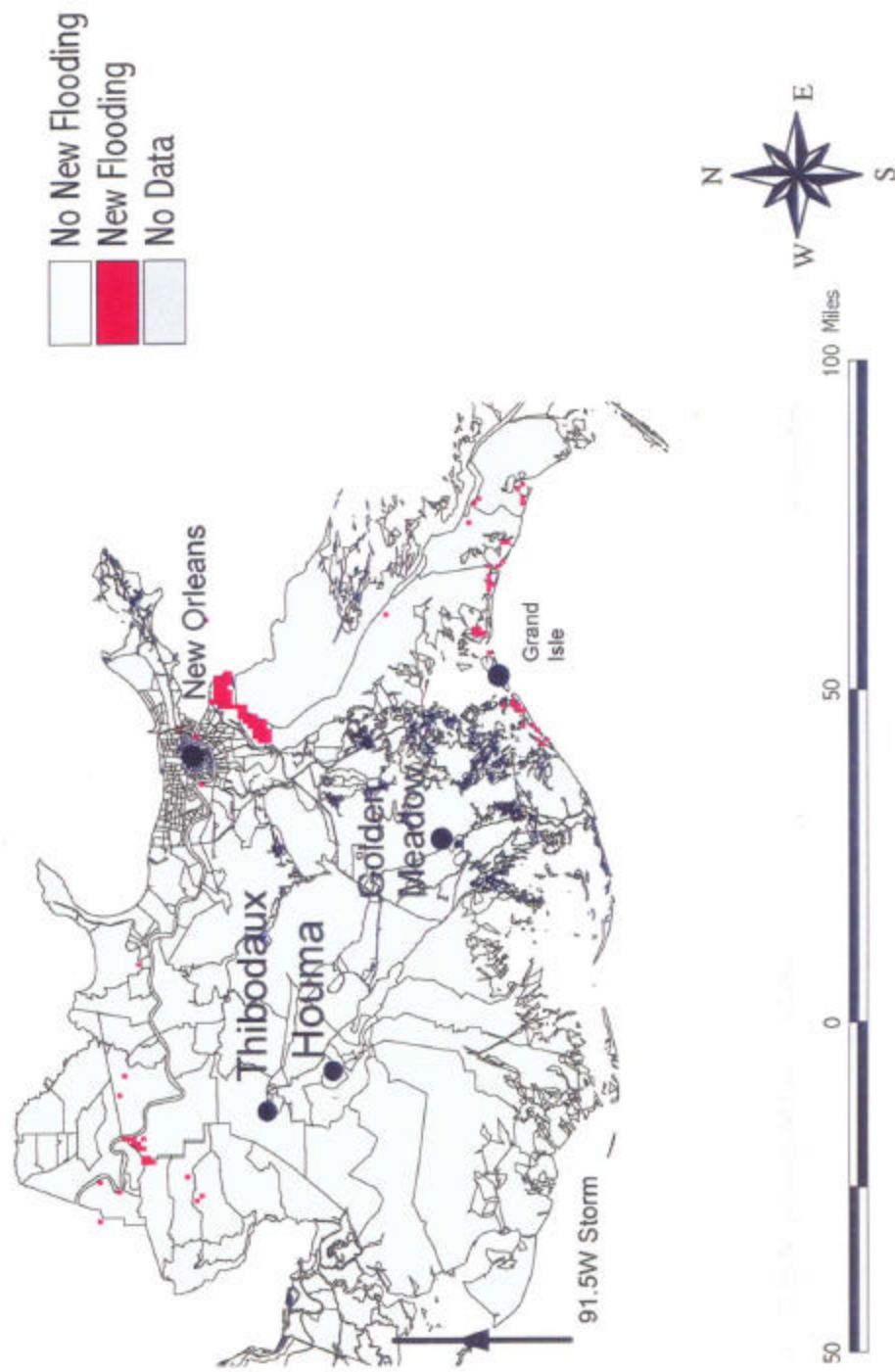


Figure 6-11. Areas Newly Flooded by 91.5 W Storm in 100 Years Under No-Action, But Not Currently Flooded in 91.5W Storm.



Average wave heights were also modeled under normal conditions. As noted above, there was too little difference in these elevations to perform any meaningful economic analysis. This is not to say there were not differences; only that the resolution of the economic data was not high enough to perform any analysis of these wave heights.

6.3. Flood Damages To Structures

This section of the report estimates the impact of barrier island project alternatives on flood damages to structures from the two prototype storms. These estimates use a damage function developed from data provided by the US Army Corps of Engineers (USACE) and from the US Bureau of the Census. The damage function is then applied to the storm surge flood-depths obtained from the hydrologic modeling outlined in Section 6.2.

6.3.1. Flood Damage Data

The USACE has developed flood stage-damage functions for Water Resource Units (WRU) in some regions of coastal Louisiana (USACE 1994). These stage-damage functions show structural damages to properties under varying flood stages. Structural damage categories include:

- * residential (including mobile homes)
- * commercial
- * industrial
- * public
- * farm buildings
- * automobiles

Damages to public structures would include damages to schools and other public buildings, but not to public infrastructure, such as roads and piers. These damages are presented in 1993 price levels and are used directly for this report. For example, WRU

148A (near Morgan City) has 5863 1 or 2 story residential structures, 610 commercial and industrial structures and an estimated 5,863 automobiles at risk (it was assumed that each household would leave one vehicle at their residence when evacuating). Total structural damages from various flood stages were estimated to be:

Stage Elevation	Damages (\$1000's)
4.0 ft (1.2 m)	\$0.0
5.0 ft (1.5 m)	\$847.5
6.0 ft (1.8 m)	\$4,377.0
7.0 ft (2.1 m)	\$25,589.7

Flood damages do not begin until elevations reach 1.2 meters (4.0 feet); and they increase more than proportional to elevation (USACE 1994).

The stage-damage data presented in the USACE study were used to establish a statistical damage function. The functional form presumed a logistic function, whereby damages first increase more than proportional to flood-depth then eventually less than proportional to flood-depth, reaching a maximum ceiling damage level. This is reasonable as location patterns would suggest more properties at risk as flood levels rise, but only a maximum amount of damage can be done. The functional form also presumed that damages would be proportional to residential structures in a WRU. This implies that commercial, industrial and public structures at risk are assumed to be proportional to residential structures. While this residential proportion-logistic function is reasonable theoretically, other functional forms were tested.

Data for the six WRU's published in the USACE study were used to estimate the logistic function. The regression procedure in SAS(resulted in the following estimation:

$$\log(\text{Damages}) = 1.443852 - 2.710987 \times (1/\text{Flood-depth}) + 0.11726 \times \log(\text{Residences})$$

$$(t=1.346) \quad (t=-7.493) \quad (t=6.746)$$

Adjusted R-sq = 0.50; N=92

Damages were total damages to structures in a WRU; and Residences were the number of 1 or 2 story residential units in the WRU, published in the same USACE report. Flood-depth was flood-stage elevation minus the elevation at which damages became positive. So this variable represents depth of water above land, not flood elevation. Use of this variable was necessary in order to use the LSU modeled depth of flood data, which were not flood elevations but depth of flood above land. This estimating model explained one-half of the variance in the data. The coefficient for $\log(\text{Residences})$ was not significantly different from 1, implying damages are proportional to residential units. Other function forms did not have as high R-sq values as this logistic function.

6.3.2. Flood Damage Estimates

Flood damages were estimated for all storm and project scenarios using the damage function presented in Section 6.4. Damages were estimated by census tract. The census tract data for the variable "residences" in the damage function equation was the total number of unattached (non-mobile home) residential structures in a tract. This is the census statistic most like the 1 and 2 story structures used to estimate the damage function. This statistic was obtained from the Wessex(census database and software. It is important to note that mobile home damages are included in the variable, Damages, in the damage function, so damages to these structures are included in the estimates.

The flood variable "Flood-depth" in the damage function was estimated for each census tract. The average flood-depth for a tract was obtained by applying the ArcView(procedure, Summarize Zones, to the flood scenarios modeled by the LSU project team. Both mean and median flood-depths were estimated for each census tract in the study area. They were estimated for both prototype storms, and for each of the barrier island project assumptions.

Table 6-8 shows estimated flood damages in each study area parish from the 90.5W storm. These include damages to residential (including mobile homes), commercial, industrial and public structures. For example, the expected flood damage using mean flood-depths to Ascension parish, if there is such a storm at present is shown in Column 1, is \$15.588 million. Expected damages, using median flood-depths, are \$6.117 million. The estimate using median depths is substantially lower than the estimate using mean depths in this case. In other instances, such as the estimate for Plaquemines parish, the estimate using the median is slightly higher than the estimate using the mean flood-depths. The bottom row of Columns 1 and 2 show estimated total damages in the study area from a current 90.5W prototype storm to be between \$862.361 and \$928.388 million.

Columns 3 through 8 of Table 6-8 show estimated damages from a 90.5W prototype storm in 100-years under different barrier island project assumptions. These estimates presume a constant coastal population distribution and number of residential structures over this time period; i.e., a fixed number of residences in the same census tracts (the basis of this assumption was provided in the Introduction). For example, Column 3 shows that a prototype Category 5 storm would result in an estimated \$15.589 million in structural damages to Ascension parish in 100-years under a no-action plan, when mean flood-depths are used as the basis for estimation. This is roughly equivalent to the damages to Ascension parish under a similar storm occurring currently, shown in Column 1. However, Column 3 shows that damages to Jefferson, Lafourche and Terrebonne parishes would be substantially higher for a storm which occurs in 100-years under the no-action plan than a similar storm occurring currently. The total damages from the 90.5W prototype Category 5 storm occurring in 100-years under the no-action plan, using mean depths, are expected to be \$987.604 million, as shown in Column 3.

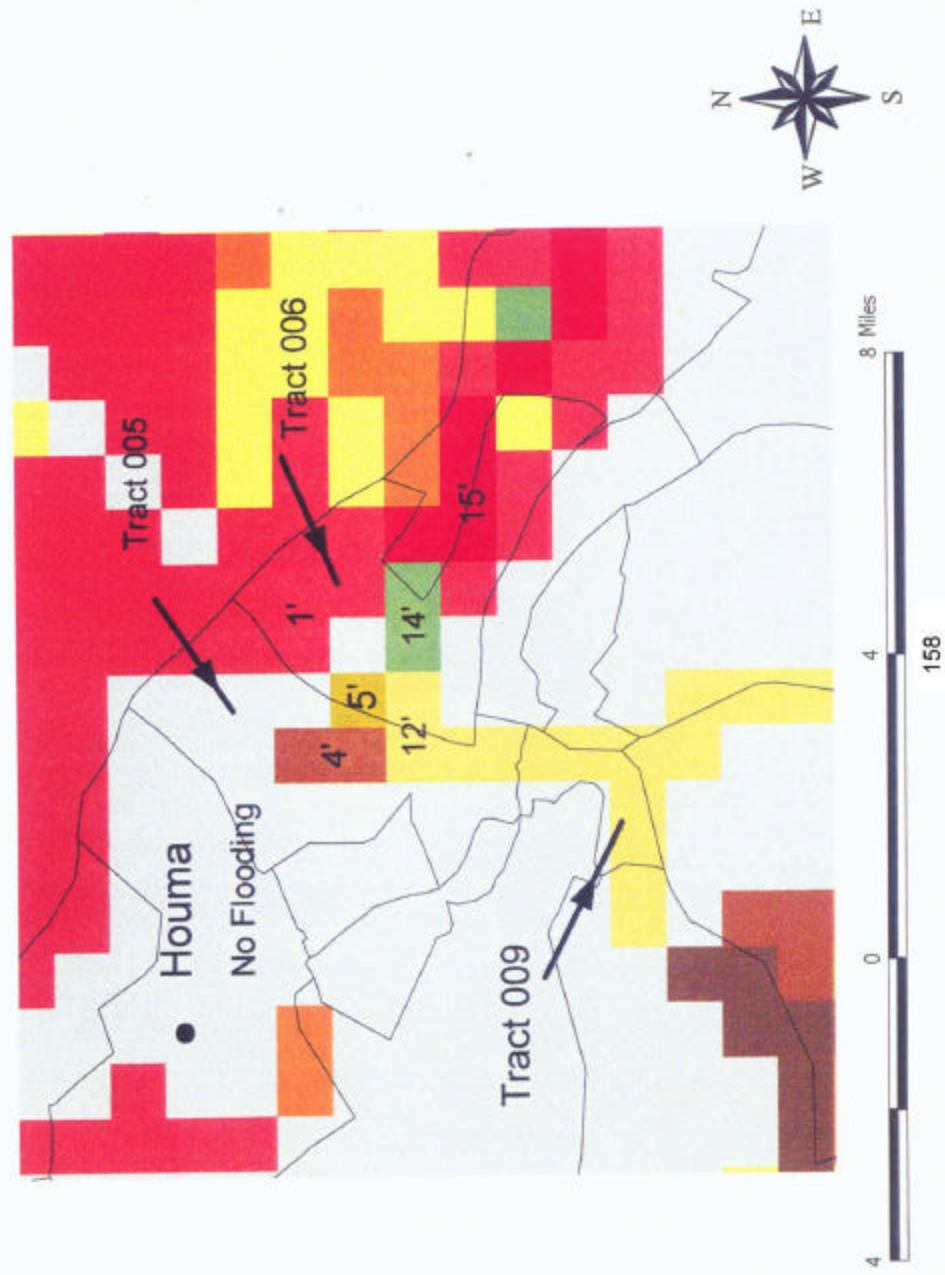
Table 6-8. Estimates of Flood Damages to Residential, Commercial, Industrial and Public Structures from the 90.5W Storm

Parish	Current Condition		No Action		Alternative 2		Alternative 1		Alternative 1	
	Date: Present		100 Years		100 Years		100 Years		100 Years	
	Mean \$1000's	Median \$1000's	Mean \$1000's	Median \$1000's	Mean \$1000's	Median \$1000's	Mean \$1000's	Median \$1000's	Mean \$1000's	Median \$1000's
	1	2	3	4	5	6	7	8		
Ascension	\$ 15,589	\$ 6,117	\$ 15,589	\$ 6,117	\$ 15,650	\$ 6,117	\$ 15,589	\$ 6,117		
Assumption	\$ 602	\$ 495	\$ 506	\$ 495	\$ 833	\$ 495	\$ 1,267	\$ 1,919		
Jefferson	\$ 379,403	\$ 346,814	\$ 401,756	\$ 387,280	\$ 380,410	\$ 349,056	\$ 358,666	\$ 329,817		
Lafourche	\$ 55,779	\$ 53,211	\$ 74,870	\$ 71,901	\$ 73,721	\$ 65,605	\$ 67,286	\$ 62,798		
Orleans	\$ 255,108	\$ 253,488	\$ 257,786	\$ 256,995	\$ 260,164	\$ 252,303	\$ 258,795	\$ 250,025		
Plaquemine:	\$ 34,725	\$ 35,165	\$ 35,754	\$ 36,195	\$ 34,794	\$ 35,130	\$ 33,373	\$ 34,124		
St. Charles	\$ 59,043	\$ 52,246	\$ 60,616	\$ 54,153	\$ 60,160	\$ 55,218	\$ 59,559	\$ 52,246		
St. James	\$ 18,145	\$ 17,870	\$ 18,715	\$ 17,870	\$ 18,625	\$ 17,870	\$ 18,669	\$ 17,870		
St. John	\$ 66,951	\$ 64,403	\$ 67,270	\$ 64,403	\$ 67,125	\$ 64,403	\$ 67,088	\$ 64,403		
St. Mary	\$ 22,711	\$ 12,017	\$ 22,687	\$ 12,017	\$ 23,255	\$ 12,017	\$ 22,687	\$ 12,017		
Terrebonne	\$ 20,332	\$ 20,535	\$ 32,055	\$ 31,746	\$ 61,351	\$ 44,496	\$ 30,752	\$ 30,767		
TOTAL	\$ 928,388	\$ 862,361	\$ 987,604	\$ 939,172	\$ 996,088	\$ 902,710	\$ 933,731	\$ 862,103		

Storm damages under no-action can be compared to the \$928.386 million in damages under a similar storm occurring currently, shown in Column 1 of Table 6-8. In other words, a no-action plan would result in \$59.218 million more damages from a storm in 100-years than the same storm occurring currently. This increase in damages is attributable to two factors. The hydrologic modeling, that is the basis for this estimate, allows two phenomena to occur over this 100-year period. First, the barrier islands are permitted to deteriorate naturally under the no-action assumption. Secondly, subsidence, sea-level rise and wetlands disintegration are also permitted to continue naturally. This means that the increased storm damages are due to these two factors jointly; i.e., not simply to the no-action.

Median depths of flooding can also be used as a basis for estimating flood damages. The median may be a superior statistic to represent the average depth. This is because the mean can be highly skewed by a few extremely large or small values. An example of this problem is illustrated in census tracts near Houma. Figure 6-12 shows that census tract 006 has most of its area flooded at a depth of 0.30 meters (1.0 feet). However, there are several pixels with very high flood-depth predictions: 1 pixel at 3.66 meters (12.0 feet), two pixels at 4.27 meters (14.0 feet) and 1 pixel at 4.57 meters (15.0 feet). The mean depth is 1.02 meters (3.3 feet) but the median depth is only 0.30 meters (1.0 feet). The median is more representative of flood-depth in this tract. This type of situation is typical of many of the census tracts in the study area. Therefore, the median based damage estimates are likely to be more appropriate than the mean based estimates.

Figure 6-12. Zoomed View of Flood Depths from 90.5W Storm in 100 Years for Terrebonne Parish Under Alternative 2.



Median based damage estimates for the 90.5W storm, \$862.361 million, are shown for a current storm in Column 2 of Table 6-8. The corresponding 100-year no-action median damage estimates, \$939.173 million, are shown in Column 4. Table 6-8 also shows damage estimates for other barrier island project assumptions. Columns 5 and 6 show estimated damages under Alternative 2; and Columns 7 and 8 show damages under Alternative 1. These estimates are used as the basis for establishing comparisons of damages under different project assumptions in the following section.

Table 6-9 shows flood damage estimates for various project assumptions using the prototype Category 5 storm reaching landfall at 91.5W. Damage estimates for this storm are slightly lower than for the 90.5W storm shown in Table 6-8. For example, the mean and median total damages from a storm occurring currently (Columns 1 and 2) are \$876.670 and \$787.636 million, respectively, compared to \$928.386 and \$862.361 million, respectively, from the 90.5W storm in Table 6-8. Table 6-9 also shows expected damages under the various project alternatives.

6.3.3. Comparing Flood Damage Estimates for Different Project Assumptions

Tables 6-8 and 6-9 can be used to establish damage comparisons across project assumptions. Table 6-10 shows these median flood damages under the two prototype storms and project alternatives. For example, under a storm occurring at present with Current Conditions of the barrier islands, a 90.5W storm will cause an estimated \$862.361 million in damages. If the same 90.5W storm occurs in 100-years, during which the no-action alternative prevailed, the flood damages would be \$939.173 million. The same storm occurring in 100-years under Alternative 1 would cause \$862.103 million in damages, and under Alternative 2 would cause \$902.710 million in damages. Table 6-10 shows comparable storm flood damages estimates for the 91.5W prototype storm.

Table 6-13 has been constructed to permit the comparison of flood storm damage estimates under the various project alternatives. Using the data from Table 6-10, Table 6-

11 shows that damage in 100-years under no-action would be \$77.070 million greater than damages in 100-years under Alternative 1 for a 90.5W storm. This means Alternative 1 would save \$77.070 million in flood damages compared to no-action if such a storm occurred in 100-years. For the same type of storm, Table 6-11 shows that damages in 100-years under no-action would be \$36.463 million greater than damages in 100-years under Alternative 2. Similarly, Table 6-11 shows that damage costs under Alternative 1 would be \$136.377 million lower than under no-action for the 91.5W storm; and damage costs under Alternative 2 would be \$74.795 million lower than under no-action.

Table 6-9. Estimates of Flood Damages to Residual, Commercial, Industrial and Public Structures from the 91.5W Storm

Parish	Current Condition		No Action		Alternative 2		Alternative 1	
	Date: Present		100 Years		100 Years		100 Years	
	Mean \$1000's	Median \$1000's	Mean \$1000's	Median \$1000's	Mean \$1000's	Median \$1000's	Mean \$1000's	Median \$1000's
	1	2	3	4	5	6	7	8
Ascension	\$ 25,978	\$ 17,670	\$ 26,136	\$ 18,187	\$ 26,110	\$ 17,670	\$ 26,120	\$ 17,670
Assumption	\$ 25,737	\$ 22,061	\$ 27,238	\$ 24,287	\$ 25,846	\$ 22,681	\$ 25,553	\$ 22,681
Jefferson	\$ 249,478	\$ 235,284	\$ 290,690	\$ 282,847	\$ 252,679	\$ 236,667	\$ 216,232	\$ 200,317
Lafourche	\$ 123,345	\$ 119,266	\$ 134,935	\$ 131,458	\$ 127,581	\$ 123,998	\$ 122,755	\$ 116,797
Orleans	\$ 111,680	\$ 91,402	\$ 115,327	\$ 95,779	\$ 133,029	\$ 95,027	\$ 128,446	\$ 85,377
Plaquemine:	\$ 26,014	\$ 20,102	\$ 31,138	\$ 31,318	\$ 28,565	\$ 20,102	\$ 24,261	\$ 19,817
St. Charles	\$ 54,344	\$ 33,006	\$ 59,233	\$ 38,766	\$ 56,541	\$ 35,654	\$ 55,443	\$ 34,106
St. James	\$ 10,682	\$ 8,100	\$ 11,829	\$ 8,951	\$ 10,945	\$ 8,100	\$ 10,743	\$ 8,100
St. John	\$ 31,478	\$ 29,226	\$ 31,806	\$ 29,716	\$ 31,592	\$ 29,226	\$ 34,279	\$ 32,209
St. Mary	\$ 51,649	\$ 46,403	\$ 51,425	\$ 46,403	\$ 51,000	\$ 46,403	\$ 50,899	\$ 46,403
Terrebonne	\$ 166,285	\$ 165,116	\$ 172,611	\$ 171,149	\$ 170,456	\$ 168,540	\$ 160,311	\$ 159,007
TOTAL	\$ 876,670	\$ 787,636	\$ 952,368	\$ 878,861	\$ 914,344	\$ 804,068	\$ 855,042	\$ 742,484

Table 6-10. Median Flood Damages Under Two Prototype Storms and Project Alternatives (\$millions)

	90.5W Storm	91.5W Storm
Present Storm Under Current Conditions	\$862.361	\$787.636
Damages in 100-years Under:		
No-action	\$939.173	\$878.862
Alternative 1	\$862.103	\$742.485
Alternative 2	\$902.710	\$804.067

Table 6-11. Comparison of Median Flood Damage Estimates in 100-years for Project Alternatives (\$millions)

	90.5W Storm	91.5W Storm
Damage in 100-years Under No-action MINUS Damage in 100-years Under Alternative 1	\$77.070	\$136.377
Damage in 100-years Under No-action MINUS Damage in 100-years Under Alternative 2	\$36.463	\$74.795

It is very important to recognize what Table 6-11 shows. It shows only the potential flood damage cost savings under the two project alternatives compared to no-action if a prototype storm hits the study area in 100-years. It tells us nothing about the probabilistic damage savings; i.e., expected damage savings considering the likelihood of the storm event. It also tells us nothing about damage cost savings in 30- or 50-years.

6.3.4. Using Flood Damage Estimates for Evaluating Benefits of Alternatives 1 and 2

The flood damage estimate comparisons presented in Section 6.3.3 can be used to estimate benefits of project alternatives. However, using them is not straightforward.

First, these comparisons are based on damage estimates for storms occurring 100-years from the present. Project evaluation procedures require annual comparisons of circumstances over a 30-year period rather than a snapshot comparison for an event in 100-years. A 30-year comparison requires some method of interpolating results from a 100-year analysis to an annual 30-year period. Second, benefits of project alternatives should be expected benefits; based on both the expectations of the effects of hydrologic changes, modeled for use in this study, as well as expectations that the events modeled will occur. Expected benefits are probabilistic, based on probabilities that the events analyzed will occur. Third, the storms analyzed are Category 5 hurricanes. Analyses were not performed for storms of varying intensities. The estimated comparisons are only valid for this one type of storm, so this cannot be used to represent other storms.

The reason this study based its analysis on the storm event in 100-years is that changes in flooding regimes over a 30-year period were anticipated to be small relative to the statistical procedures that would be used in the study. For example, it was anticipated that mean values could not be used as reasonable basis for estimation and that median values were a better basis. Also, continuous flood depth data had to be grouped into integer (1', 2', 3', etc.) categories for analysis by the GIS. This meant that depth changes less than 0.2 meters (0.5 ft) would become lost in the statistical procedures. We can interpolate to 30-years by assuming that hydrologically related damages would increase linearly over time. This means that if Alternative 2, compared to no-action, would save \$36.463 million (Table 6-11) when the prototype storm event occurred in 100-years, it would save 30% of that amount, \$10.939 million, if the storm event occurred in 30-years. It would save 15% of that amount, \$5.469 million, if it occurred in 15-years. Of course, the linearity assumption underestimates savings at 30-years if most of the hydrologic changes were to occur early in the 100-year period; and, conversely, overestimates savings for the opposite case. Table 6-12 makes this interpolation in estimates of damage cost savings under the project alternatives for the 30-year period of analysis.

Expected damage cost savings represents the product of savings when a storm event occurs times the probability of that event:

Expected Damage Cost Savings = Cost Savings When Event Occurs x Probability of Event

Section 6.3.3 has estimated the cost savings when a storm event occurs (i.e., the estimates in Tables 6-11 and 6-12). The storm event modeled was a Category 5 hurricane. This magnitude storm is rare in the study area. Only one such storm has directly hit the study area during the period 1900-1992 (Federal Emergency Management Agency 1994). During this period, a total of 11 storms (Category 1-5) have directly hit within the latitudes 89W-91W which encompass the study area. Unfortunately, we do not have hydrologic data to make estimates for damages from non-Category 5 storms. Given the rarity of a Category 5 storm and the fact that we do not have estimates of damages for lesser storms, we do not feel it is appropriate to estimate the Expected Damage Cost Savings.

Table 6-13 uses the 30-year damage cost savings from Table 6-12 to estimate the present values of those savings using various discount rates. For example, using the US Army Corps of Engineers 8.25% discount rate applicable for 1993 (USACE 1994), Table 6-13 shows that the present value of damages in 30-years under no-action MINUS damages in 30-years under Alternative 1 is \$2.144 million for the 90.5W storm. The present value of damage cost savings for Alternative 2 is \$1.014 million using the same discount rate. The 91.5W storm cost savings under the two alternatives are greater than the 90.5W storm savings. Lower discount rates increase the present values of the damage cost savings.

Table 6-12. Comparison of Median Flood Damage Estimates in 30-years for Project Alternatives - Interpolated Estimates from Table 6-8 (\$ millions)

	90.5W Storm	91.5W Storm
Damage in 30-years Under No-action MINUS Damage in 30-years Under Alternative 1	\$23.121	\$40.913

Damage in 100-years Under No-action		
MINUS Damage in 100-years Under		
Alternative 2	\$10.939	\$22.439

Table 6-13. Present Value Comparison of Median Flood Damage Estimates in 30-Years for Project Alternatives (\$millions)

	90.5W Storm:			91.5W Storm:		
	8.25%	5%	3%	8.25%	5%	3%
Damage in 30-years Under No-action						
Minus Damage in 30-years Under	\$ 2.144	\$ 5.350	\$ 9.526	\$ 3.793	\$ 9.466	\$16.856
Alternative 1						
Damage in 30-years Under No-action						
Minus Damage in 30-years Under	\$ 1.014	\$ 2.531	\$ 4.507	\$ 2.080	\$ 5.192	\$ 9.245
Alternative 2						

6.4. Other Cost Impacts of Barrier Island Projects

The impacts of project alternatives on structural damage costs from flooding are likely to be the most significant monetary benefits associated with barrier island restoration and maintenance. These project impacts were estimated in Section 6.3, and included cost savings to residential, commercial, industrial and public infrastructure. However, there may be other monetary benefits from barrier island projects. These would include:

* oil and gas infrastructure cost savings

- * highway and street maintenance cost savings
- * water supply cost savings
- * agricultural crop flood damage cost savings

In addition to these monetary benefits, there may be non-monetary benefits from the preservation of lifestyles and social relations for coastal residents whose residence and employment are barrier island dependent.

While these monetary and non-monetary benefits may be very real, they are more difficult to estimate than structural damage benefits. This is because of data availability problems as well as conceptual measurement problems. Very ad hoc assumptions may have to be made to make estimates of these benefits. This section attempts to address several of these benefits that are likely to be somewhat quantifiable.

6.4.1. Oil and Gas Infrastructure

Oil and gas infrastructure (wells, pipelines, processing plants, compressor and metering stations, etc.) face increased storm risk as the barrier islands deteriorate. Changes in normal wave contours predicted under barrier island loss should not be so severe as to adversely impact structures in open water. The loss of barrier islands would diminish their usefulness as anchors for pipelines; requiring reburial. This could be a substantial cost. Pipelines traversing wetlands may have to be reburied if protected marshland areas convert to open water. Storm impacts from increased tidal surge elevations could require some redesign of well structures in open water.

The primary hydrologic and geologic effects of proposed barrier island projects are storm surge protection of open water and inland areas, and barrier island stabilization and wetland loss protection. Barrier island stabilization has the straightforward benefit of providing an anchor point for offshore oil and gas pipelines; barrier island loss would require more expensive engineering of these pipelines. Current and future oil and gas

wells located in open waters landward of the barrier islands benefit from barrier island stabilization insofar as the islands moderate tidal surge heights.

6.4.1.1. Barrier Island Pipeline Reburial Costs

Barrier islands are anchoring structures for some offshore pipelines. There are currently nearly 60 pipelines coming onshore in the study area comprising the Terrebonne-Timbalier Bay and the Barataria Bay complexes. They range in size from 15 cm to 91 cm, with an average size of 41 cm. These are the pipelines most vulnerable to the projected barrier island losses in these complexes. Pipeline reburial occurs regularly as lines rise and washovers remove line cover. However, this reburial rate would increase as barrier islands disintegrate. We cannot predict how much more frequently and how much more severe reburial will be.

Increases in barrier island pipeline reburial costs were estimated for the 30- and 100-year no-action scenario in Step H (LADNR 1998h.ii). These estimates assumed that 60 lines currently crossing the islands would have to be reburied in 30-years at a reburial cost of \$1.2 million at that time. The present and annualized values of those costs are shown in Table 6-14. For example, barrier island related pipeline reburial costs are estimated to have a present value of \$0.11 million, using the USACE 8.25% discount rate, and \$0.49 million using a 3% discount rate. Annualized values range from \$0.01 million per year using the 8.25% discount rate to \$0.03 million per year using the 3% discount rate.

Table 6-14. Expected Barrier Island Pipeline Reburial Costs for No-action Compared to Current Conditions (\$ millions)

Discount Rate	Current Condition Compared to:	No-action 30-years	No-action 100-years
	2	3	4
1			

8.25%	Present Value	\$0.11	\$0.12
	Annualized Value	\$0.01	\$0.01
5.00%	Present Value	\$0.28	\$0.34
	Annualized Value	\$0.02	\$0.02
3.00%	Present Value	\$0.49	\$0.70
	Annualized Value	\$0.03	\$0.04

We make the assumption that either Alternative 1 or Alternative 2 would avoid these reburial costs. The estimates in Table 6-14 would then be benefits of these Alternatives. However, we assume no additional benefit of Alternative 1 over Alternative 2. (At least these benefits would be too small to be measurable using the very crude procedures employed in this study.)

6.4.1.2. Wetlands Pipeline Reburial Costs

Many miles of pipeline also run through the coastal wetlands. For example, there are roughly 1,207.5 kilometers (750 miles) of pipelines, ranging from 13 cm to 91 cm (5 to 36 inch) lines, running through the wetlands region adjacent to the Terrebonne-Timbalier and Barataria Bays. These estimates were calculated from pipeline maps and include all pipelines within approximately 8 km (5 miles) of these bays. These wetlands provide some protection against wave action and storms. Loss of wetlands may require the repositioning of vulnerable lines, including reburial.

The increases in interior wetlands pipeline reburial costs were estimated for no-action compared to current conditions in Step H (LADNR 1998h.ii). These estimates are reproduced in Table 6-15. Pipeline reburial cost savings of project alternatives can be estimated by assuming these savings, relative to the costs of no-action, are proportional to the wetlands saved by the project alternatives relative to wetlands lost under no-action. For example, 30-year wetlands losses under no-action were estimated in Step G (LADNR 1998g) to be 58,630 hectares (144,877 acres), and can be estimated using Table 6-1.

Wetland losses under Alternative 1 were estimated to be only 55,018 hectares (135,952 acres) during this 30-year period. This implies that wetlands losses under Alternative 1 were 6.0% less than under no-action. Therefore, we assume that pipeline reburial costs under Alternative 1 would be 6.2% less than under no-action. Table 6-15 shows that the present value of reburial costs in interior wetlands would be \$4.064 million, using the 8.25% discount rate over a 30-year period. Therefore, reburial costs under Alternative 1 would be \$0.25 million (6.2% x \$4.064) less than under no-action. This cost savings is shown in Column 5 of Table 6-16.

Table 6-15. Expected Interior Wetlands Pipeline Reburial Costs for No-action Compared to Current Conditions (\$ millions)

Current Condition Compared to:		No-action 30-years	No-action 100-years
Discount Rate			
1	2	3	4
8.25%	Present Value	\$4.064	\$4.478
	Annualized Value	\$0.370	\$0.370
5.00%	Present Value	\$5.682	\$7.336

	Annualized Value	\$0.370	\$0.370
3.00%	Present Value	\$07.244	\$11.679
	Annualized Value	\$0.370	\$0.370

Table 6-16. Interior Wetlands Pipeline Reburial Cost Savings from Project Alternatives (\$ millions)

Losses MINUS		Wetlands		8.25%		5.00%		3.00%	
Under Losses	Period	Loss	Present	Annualized	Present	Annualized	Present	Annualized	
Under	(Years)	Avoided	Value	Value	Value	Value	Value	Value	
No-action Alternative 1	30	6.2%	\$0.25	\$0.02	\$0.35	\$0.02	\$0.45	\$0.02	
	100	6.0%	\$0.27	\$0.02	\$0.44	\$0.02	\$0.70	\$0.02	
No-action Alternative 2	30	0.5%	\$0.02	\$0.00	\$0.03	\$0.00	\$0.04	\$0.00	
	100	2.7%	\$0.12	\$0.01	\$0.20	\$0.01	\$0.32	\$0.01	

The cost savings for Alternative 2 compared to no-action are also shown in Table 6-16, as are savings for Alternative 1 compared to Alternative 2. These savings are small compared to the storm, recreational and commercial fisheries benefits of project alternatives.

6.4.1.3. Oil and Gas Wells and Related Structures

There are roughly 340 oil and gas fields and nearly 19,000 wells in the study area, with 270 fields and over 17,000 wells located in the five parishes adjacent to the barrier islands (LADNR 1998f). The associated well structures may be subject to greater washover intensities from storms in the absence of protective barrier islands. If these inland structures are typically built to withstand washovers, there will be no increased engineering and maintenance costs to these inland well structures from increased tidal surge elevations. Figures 6-4 and 6-5 suggest these increased tidal elevations would typically range up to 0.30 meters (1.0 feet) in the regions immediately adjacent to the barrier island complexes.

Wells and associated structures in open waters lying landward of the barrier islands may be subject to substantial increased storm risk in the absence of those protective islands. In the Step H report (LADNR 1998h.ii), there are 4,166 such wells in fields located in open waters in Terrebonne-Timbalier and Barataria Bays. While these are the wells at risk, estimating increased costs to these wells under alternative project scenarios is problematic. The report also estimates the expected well platform construction cost increases for these bayside wells under no-action compared to Current Conditions are shown in Table 6-17.

Table 6-17. Expected Well Platform Construction Cost Increases for Anticipated Bayside Wells Under No-Action Compared to Current Conditions (\$ millions)

Losses Under	Period (Years)	8.25%		5.00%		3.00%	
		Present Value	Annualized Value	Present Value	Annualized Value	Present Value	Annualized Value
No-action	30	\$0.269	\$0.024	\$0.355	\$0.023	\$0.436	\$0.022
	100	\$0.269	\$0.024	\$0.355	\$0.023	\$0.436	\$0.022

We assume that both Alternatives 1 and 2 will avoid the need for bayside well platform construction that would arise under no-action. This is because these alternatives essentially provide the same barrier island protection against surges and wave action as the islands in the current conditions. Therefore, the cost savings of these alternatives would be the no-action cost increases compared to Current Conditions as shown in Table 6-18. For example, Alternatives 1 and 2 would provide costs savings of \$0.269 million over no-action, using the 8.25% discount rate. The cost savings are the same for both alternatives, since the Step H Report assumed that all additional well construction costs would accrue within the 30-year period due to the age of the fields in the impacted area (LADNR 1998h.ii). In addition, Alternative 1 is expected to provide no construction cost savings over Alternative 2.

Table 6-18. Expected Well Platform Construction Cost Savings for Anticipated Bayside Wells Under Project Alternatives (\$ millions)

Losses MINUS	8.25%	5.00%	3.00%
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Under	Losses	Period	Present	Annualized	Present	Annualized	Present	Annualized
	Under	(Years)	Value	Value	Value	Value	Value	Value
No-action Alternative 1		30	\$0.269	\$0.024	\$0.355	\$0.023	\$0.436	\$0.022
		100	\$0.269	\$0.024	\$0.355	\$0.023	\$0.436	\$0.022
No-action Alternative 2		30	\$0.269	\$0.024	\$0.355	\$0.023	\$0.436	\$0.022
		100	\$0.269	\$0.024	\$0.355	\$0.023	\$0.436	\$0.022

6.4.1.4. Oil and Gas Refineries and Processing Plants

There are five active refineries and 23 gas processing plants in the study area (LADNR 1998f). Estimation of potential flood damage costs to these structures is problematic. However, flood damage estimation methodology used in Section 6.3 included damages to industrial structures insofar as these structures were included in the USACE estimates. However, there is reason to believe that costs to refineries and processing plants are likely to be omitted using that methodology. The reason is that damages were tied to residential units in the WRU's (Water Resource Units) studied by the USACE. Refineries and processing plants in coastal Louisiana are likely to be isolated from residences so the residential based methodology used in Section 6.3 may omit, or undervalue, damages to these industrial structures. Damages to these unique structures would have to be estimated using a typical refinery and processing plant. We do not know of any study that has made such an estimate. While there may be effects of project alternatives on flood damage costs to these structures, we are not able to estimate them.

6.4.2. Highway and Street Maintenance

The increased possibility of flooding may impact road and street maintenance expenses. However, the manner in which this may occur is not obvious. The depth of flooding of roads is not as important in determining road damages as whether the road is flooded at all, the flow rate of water across the road and flood duration. Figures 6-10 and 6-11 show those portions of the study area, called flood risk margins, that are more likely

to be flooded from one of the prototype storms under the no-action alternative in 100-years than would be the case for a current storm. Figure 6-13 reproduces those areas of increased flooding likelihood and adds a data layer of highways and streets from the Wessex(database of Tiger 92 street files. The streets in these areas are at risk from greater flooding under no-action compared to current conditions.

These increased inland flood risks under no-action are due to a combination of factors, including sea level rise, wetland subsidence and the loss of barrier islands under no-action. Sea level rise and wetlands subsidence will continue regardless of the barrier island projects. It is probably for this reason that the hydrologic models did not yield substantially different flood risk margins under no-action, and Alternatives 1 and 2 (See Section 6.2). The risk margins were so small that we could not reasonably estimate differences in highways and streets flooded between the no-action scenario and Alternatives 1 and 2.

6.4.3. Water Supply

Public water supplies in the study area rely on both groundwater and surface waters (LADNR 1998f). Alterations of the barrier islands may periodically change salinity regimes of surface waters and make some water supplies unreliable. Furthermore, permanent changes in salinity levels and movement of salinity isoclines landward may alter salinity levels of groundwater supplies. The Step H Report (LADNR 1998h.ii) estimated the increases in water supply costs for no-action compared to current conditions. Since water supply problems are more likely to arise from sea level rise and wetlands subsidence, they may not be mitigated by barrier island projects. Therefore, we assume that the drinking water costs under no-action and Alternatives 1 and 2 will be the same.

6.4.4. Agricultural Crop Flood Damages

Increased flood damages to agricultural crops could be due to two effects: inundation of previously unflooded lands, and longer inundation periods. These are two separate effects. We have no data on length of flooding under the various project alternatives, so this effect cannot be estimated. However, Figures 6-10 and 6-11 show newly flooded areas under no-action compared to current Category 5 storms. If any of these areas are agricultural lands, they may face increased expected flood damages to crops. Figure 6-13 shows these newly flooded lands and associated streets. The Step H Report estimated the agricultural costs of these newly flooded lands (LADNR 1998h.ii). However, as noted in Section 6.2, the marginal increases in newly flooded lands between no-action and Alternatives 1 and 2 were too small to analyze. Therefore, we presume the agricultural cost differences between these project options will be small and we cannot estimate them.

Figure 6-13. Streets Likely to be Newly Flooded by 90.5W or 91.5W Storm Under No-Action, But Not Flooded Under Current Storm.

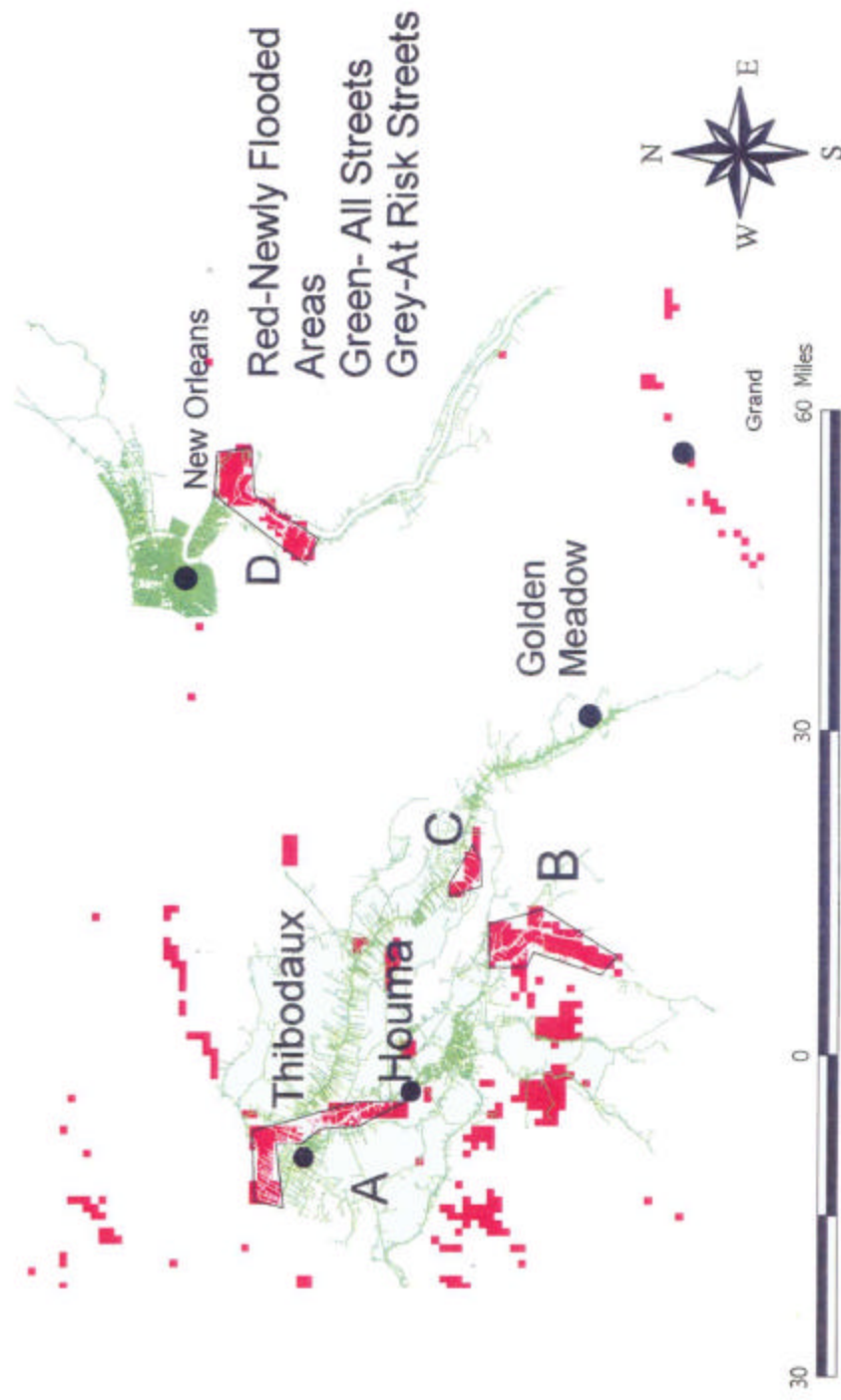
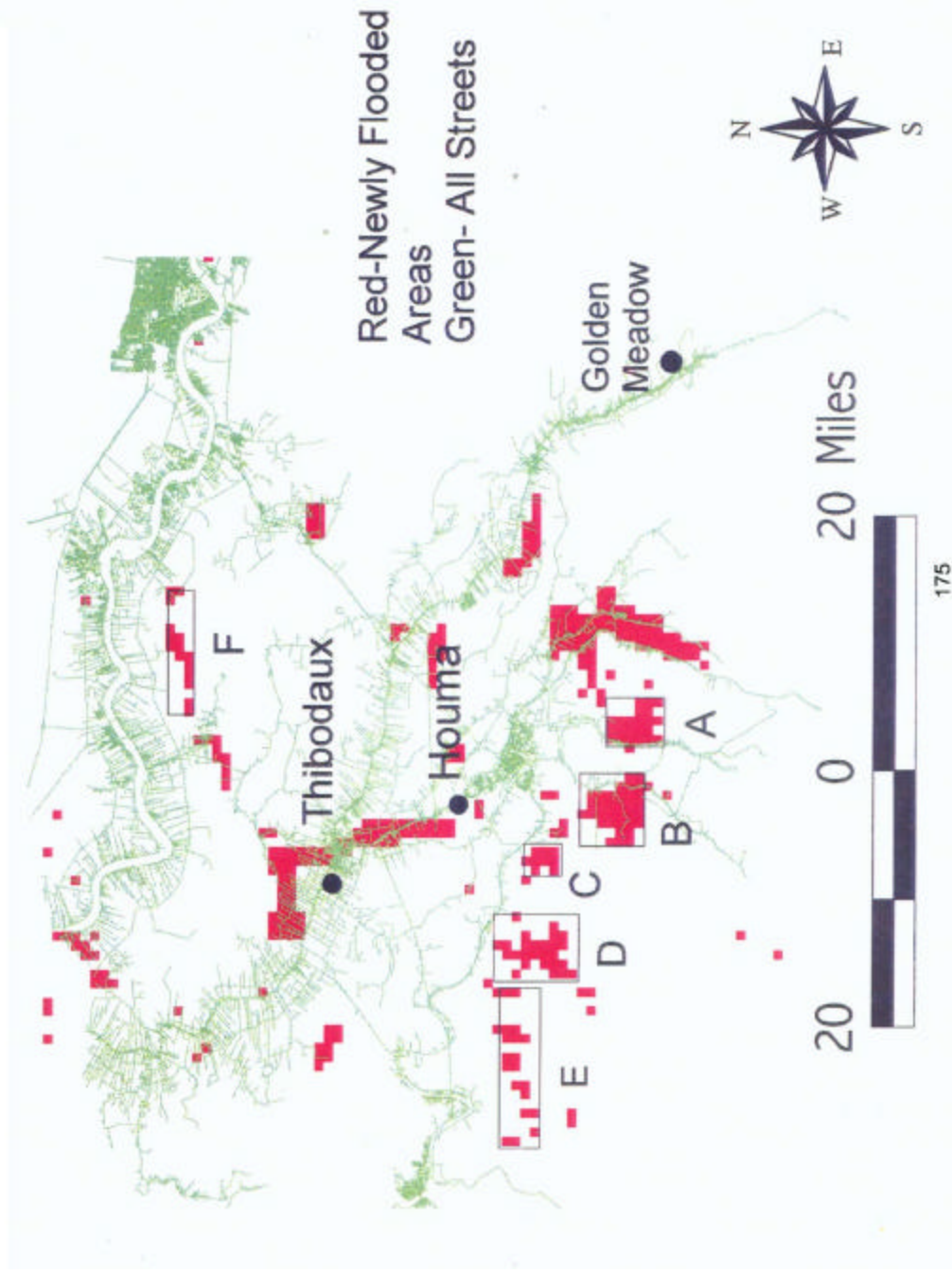


Figure 6-14. Agricultural Areas Likely to be Newly Flooded by 90.5W or 91.5W Storm Under No-Action, But Not Flooded Under Current Storm.



6.5. Summary Of Economic Benefits Of Project Alternatives

This study has estimated some of the benefits of barrier island project alternatives; or, conversely, the costs of not engaging these projects. There are three related pathways for project impacts on study area economic benefits and costs: alterations of normal and storm related hydrologic regimes, alterations of barrier island configurations, and alterations of wetland configurations. After considering the maps showing changes in normal wave conditions under project alternatives, the study concluded that economic impacts of these changes would be small. The study then focused on project impacts of storms, barrier island configurations and wetland losses.

Project alternatives included no-action, Alternative 1, and Alternative 2. Compared to no-action, the alternatives could possibly reduce economic losses from storms and wetlands deterioration. These reductions in losses would be the benefits of the alternatives compared to no-action.

Storm damages were estimated for two prototypic, Category 5 storms occurring 100-years from the present. These damages were estimated under the project alternatives. These damage comparisons are shown in Table 6-19. For example, if a Category 5 storm hit coastal Louisiana at 90.5W in 100-years, there would be \$77.1 million less flood damage under Alternative 1 than under no-action. The damage cost savings for a 91.5W storm in 100-years is \$136.4 million. Alternative 2 would result in damage cost savings compared to no-action equal to \$36.4 or \$74.8 million, depending on where the storm hit. In other words, Alternative 1 results in roughly twice the damage cost savings compared to no-action as Alternative 2. It is extremely important to understand the information provided by Table 6-19. It is only an estimate of damage savings if such a storm occurs. It is an estimate of damage savings at that time (i.e., 100-years from present).

Table 6-19. Comparison of Median Flood Damage Estimates for Storms Occurring in 100-years for Project Alternatives (\$ millions)

	90.5W Storm	91.5W Storm
Damage in 100-years Under No-action MINUS Damage in 100-years Under Alternative 1	\$77.070	\$136.377
Damage in 100-years Under No-action MINUS Damage in 100-years Under Alternative 2	\$36.463	\$74.795

Table 6-20 shows damage savings if a storm occurs in 30-years. This estimate is simply thirty percent of the 100-year damage savings estimates shown in Table 6-19. In order to understand these savings in present value terms, Table 6-21 has estimated the present value of damage cost savings if a storm occurs in 30-years. For example, the \$23.121 million in damages savings from a 90.5W storm under Alternative 1 compared to no-action for the 30-year storm, shown in Table 6-20, has a present value of \$2.1 million when using the USACE's 8.25% discount rate (USACE 1994) applicable to the base year of this study, 1993. This present value cost savings is \$9.526 million when a discount rate of 3% is used. The present value of cost savings in the case of a 91.5W storm is roughly twice as large. These values tell us the present value equivalents of the damage savings if a storm occurs in 30-years.

Table 6-20. Comparison of Median Flood Damage Estimates for Storms Occurring in 30-years for Project Alternatives (\$ millions)

	90.5W Storm	91.5W Storm
Damage in 30-years Under No-action MINUS Damage in 30-years Under Alternative 1	\$23.121	\$40.913
Damage in 100-years Under No-action MINUS Damage in 100-years Under Alternative 2	\$10.939	\$22.439

Lesser category storms were not analyzed, so storm damage benefits of alternatives would be underestimated by considering only Category 5 storms. We would have a better understanding of project alternative cost savings if we could have analyzed a range of storms, and applied probabilities to those damages based on historic storm occurrence data. Study funding limitations did not allow this.

Recreational and commercial fishery losses were associated with wetland areas. The wetland areas differed across alternatives, as barrier island configurations would impact wetlands loss rates. Other benefits of project alternatives were considered, including pipeline reburial costs, oil and gas well construction costs, highway and street maintenance, water supply and agricultural crop damages. Highway and street infrastructure damage costs savings could not be estimated given the resolution of the data available. This was also the case for water supply and agricultural damages.

Table 6-21. Present Value Comparison of Median Flood Damage Estimates for Storms Occurring in 30-years for Project Alternatives (\$ millions)

	90.5W Storm:			91.5W Storm:		
	8.25%	5%	3%	8.25%	5%	3%
Damage in 30-years Under No-action Minus Damage in 30-years Under Alternative 1	\$2.144	\$5.350	\$9.526	\$3.793	\$9.466	\$16.856
Damage in 30-years Under No-action Minus Damage in 30-years Under Alternative 2	\$1.014	\$2.531	\$4.507	\$2.080	\$5.192	\$9.245

Table 6-22 shows the summary estimates of present values of non-storm related benefits for Alternatives 1 and 2 compared to no-action. These benefits include only recreational and commercial fishery benefits, and oil and gas infrastructure benefits of the alternatives. High and low estimates were made for both 30 and 100-year periods, using difference discount rates. For example, Table 6-22 shows the non-storm present value of cost savings, or benefits, of Alternative 1 compared to no-action over this 30-year period as being \$1.6 to \$1.9 million using the 8.25% discount rate. The annualized value of this cost savings, or benefit, ranges from \$145,000 to \$168,000 per year over the 30-year period of amortization. The present value of these cost savings ranges from \$3.3 to \$3.8 million using a 3% discount rate. The present and annualized cost savings, or benefits, of Alternative 2 compared to no-action are roughly one-half the savings that Alternative 1 provides.

It is important to emphasize that Table 6-22 cannot be added to Table 6-21. Table 6-22 represents the cost savings over the next 30 or 100-years anticipated from the two project alternatives. Table 6-21 only shows the damage cost savings if a prototype storm occurs. Such a storm, while likely to occur over the next 100-years, may or may not occur. Storm damage savings from the project alternatives could only be added to Table 6-22 if we had annual estimates of the expected storm damages, taking into consideration both the damages if a storm occurs and the probability of such a storm. While such estimates are possible, they could not be made for this study due to budget limitations.

Table 6-22. Summary of Non-Storm Cost Savings and Benefits of Project Alternatives 1 and 2 Compared to No-action (\$ millions)

Losses Under	MINUS Losses Under	Period (Years)	Low/High	Present Value	8.25% Annualized Value	Present Value	5.00% Annualized Value	Present Value	3.00% Annualized Value
No-action	Alternative 1	30	Low	\$1.643	\$0.145	\$2.462	\$0.157	\$3.323	\$0.168
			High	\$1.897	\$0.168	\$2.820	\$0.178	\$3.780	\$0.188
		100	Low	\$1.844	\$0.152	\$3.348	\$0.175	\$5.848	\$0.209
			High	\$2.178	\$0.178	\$4.128	\$0.214	\$7.737	\$0.268
No-action	Alternative 2	30	Low	\$0.859	\$0.076	\$1.544	\$0.100	\$2.151	\$0.113
			High	\$0.968	\$0.086	\$1.779	\$0.115	\$2.465	\$0.128
		100	Low	\$1.057	\$0.089	\$2.148	\$0.116	\$3.691	\$0.142
			High	\$1.206	\$0.102	\$2.596	\$0.139	\$4.727	\$0.175

7.0 CONCLUSIONS

The results of the landscape mapping and hydrologic simulations indicate that the barrier island restoration alternatives will have a measurable effect on several environmental conditions in the study area. The acreage of wetland preservation associated with the barrier shoreline alternatives are 8,137 hectares (31.4 mi²) for Alternative 1 and 3,584 hectares (13.8 mi²) for Alternative 2 in 100-years.

Tidal amplitude will not be significantly reduced in the bays or marshes of the study area due to the restoration Alternatives 1 and 2. Salinity simulations for both alternatives show that values in the bays of the study area will be reduced near the barrier islands, particularly near locations where tidal passes are closed or narrowed. The change in salinity is not enough to change the type of emergent habitat. The barrier alternatives show considerably larger effects on salinity if the Davis Pond diversion is included in the simulations. Both barrier alternatives reduce hurricane flooding in the study area. The reduction is highly variable in the study area and ranges from a few percent to up to 50% for Alternative 1 and from a few percent to up to 20% for Alternative 2.

Wave impacts at the marsh shoreline can be controlled by two means: 1) reducing the gaps between adjacent barrier islands, and 2) absorbing wave energy derived from locally-generated waves and/or longer period waves propagating through the tidal passes from the Gulf of Mexico. An optimal solution would be a combination of the above two, (i.e., Alternative 1). Numerical modeling indicates that Alternative 2 would successfully reduce overall wave energy levels in the back-barrier bay, especially in the vicinity and directly landward of the previous gaps, by restricting wave propagation through these gaps. However, Alternative 2 does not provide any mitigation regarding the erosional impact of wind-generated waves inside the bay on marsh shorelines. The data presented here indicate that Alternative 1, utilizing the nearshore wave energy absorbers, will protect the marsh shoreline more effectively in terms of dissipating between on average 80 and 100% of wave energy at the marsh-water interface around the bays. Although the

numerical model predicts that Alternative 2 will reduce the potential for marsh shoreline erosion by significantly restricting wave energy, this solution does not offer any protection against wave generation in the bays driven by local winds.

Alternative 1 has the largest impact in reducing land loss. Including the creation of saline marsh on the barrier islands, Alternative 1 increases the area of saline marsh by 8,603 hectares (33.2 mi²) in 30-years and 13,127 hectares (50.7 mi²) in 100-years. An additional 1,287 hectares (5.0 mi²) and 1,439 hectares (5.6 mi²) of shore/flat habitat are increased for 30- and 100-years respectively.

Alternative 2 increases the area of saline marsh on the islands and along the bay shoreline by 2,953 hectares (11.4 mi²) in 30-years and 6,221 hectares (24.0 mi²) in 100-years. Shore/flat habitat is increased by 1,153 hectares (4.5 mi²) and 1,324 hectares (5.1 mi²) for 30- and 100-year respectively.

Alternatives 1 and 2 directly impact open water areas, such as inlets and nearshore environments by converting them to marsh and shore/flat habitat. The beach habitat created and maintained with Alternatives 1 and 2 provides nursery grounds for many species of fish. The saline marsh created and maintained on the islands provides habitat for various estuarine fish and macroinvertebrates. The beach and dune provide nesting grounds for various species of non-migratory and migratory birds. Alternative 1 has an added benefit directly attributable to the wave absorbers. The interior set of segmented breakwaters provides hard bottom habitat and shelter for invertebrates and vertebrates.

The saline marsh along the landward bay shoreline protected by Alternatives 1 and 2 increases the habitat available for resident fish species. Estuarine and marine migrants use the marsh during their first year of life. Various species of birds will also use the marsh.

Expected flood damages to residential, commercial, industry and public structures, as well as to roads, were estimated. These expected damages took into

consideration the probability that such a storm would occur. Damage costs were then compared across project alternatives using only a Category 5 storm for analysis. Lesser storms would also yield economic implications for the different project alternatives. For this reason alone, the estimated cost savings from the project alternatives must be interpreted as minimum savings. Losses to the commercial fishing industry and losses in recreational enjoyment were estimated, and the benefits of project alternatives compared for these losses. Oil and gas related losses, insofar as they could be estimated, were also compared across alternatives.

Alternative 1 reduces the flood damage in the study area by \$77.1 million for a 90.5W storm track and \$136.4 million for a 91.5W storm track compared to no-action in 100-years. Linearly interpolating these reductions yields benefits of \$23.1 and \$40.9 million compared with no-action in 30-years. Present value of these benefits ranges from \$2.1 to 16.9 million, with lower discount rates resulting in increases in cost savings.

Alternative 2 reduces the flood damage in the study area by \$36.5 million for a 90.5W storm track and \$74.8 million for a 91.5W storm track compared to no-action in 100-years. Thus, flood damage benefits of Alternative 2 compared to no-action in 30-years is \$10.9 and \$22.4. Present value of these benefits ranges from \$1.0 to 9.2 million. Therefore, Alternative 1 provides approximately twice the savings as Alternative 2.

Non-storm losses to coastal Louisiana would stem from wetland losses, and associated recreational and commercial fishery losses. They would also stem from losses in the abilities of the barrier islands to protect oil and gas infrastructure. The present value of non-storm related cost savings or benefits from Alternative 1 compared to no-action range from \$1.6 to \$3.8 million over a 30-year period. The annualized values of these savings range from \$145,000 to \$188,000 per year. As in the case of storm damage protection, Alternative 2 provides approximately half the savings or benefits of Alternative 1. The present and annualized values of these savings and benefits increase using lower discount rates.

These economic benefits estimates will represent minimum benefits of the alternatives. Only one type of storm was considered. Considering a full range of storm types, along with their probabilities, would substantially increase benefits estimates of projects. There were no attempts to estimate migration costs if projects altered the need for populations to move. There was no reasonable way to predict what population responses to future hydrologic conditions would be. Recreational loss estimates may be a low if recreational demands in coastal Louisiana increase in the future. There were no estimates for the pain and suffering associated with increased storm vulnerability, or valuations of social losses in community and culture if populations were induced to migrate.

A summary of the benefits of the alternatives compared to no-action is shown in Table 7-1.

Table 7-1. Summary of Benefits of Alternatives 1 and 2 Compared to No-action

	Alternative 1	Alternative 2
Saline marsh preserved 30-years (100-years)	3,613 hectares (8,137 hectares)	316 hectares (3,584 hectares)
Habitat created	6,348 hectares	4,008 hectares
Annualized non-storm savings 30- Years (100-years)	\$145,000-188,000 (\$152,000-268,000)	\$76,000-128,000 (\$89,000-175,000)
Storm damage savings 30-years (100-years)	\$23-41 million (\$77-136 million)	\$11-22 million (\$36-75 million)

1 hectare = 2.47 acres

1 square mile = 259 hectares

8.0. REFERENCES

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(1) The reader should note that Visser et al 1996 cited in the text should refer to the revised reference.